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THE SIMPSON DESERT EXPEDITION, 1939 SCIENTIFIC REPORTS: NO. 3, BIOLOGY – REPTILES AND BATRACHIANS

BY J. R. KINGHORN, AUSTRALIAN MUSEUM, SYDNEY (READ 12 APRIL 1945)

Summary

The reptiles and batrachians of Central Australia offer considerable interest for herpetologists because of their somewhat confusing distribution due to the nature of the country and the climatic conditions. Collections from this region are rarely large, collectors seldom have the opportunity to camp in any one locality for any length of time, and even if they do a sudden cool change sends reptiles to earth, where they remain hidden for many days in places where a white man has little chance of finding them. The Simpson Desert area would be no exception to this rule, for its chief characteristics are level plains, sandridges, an absence of surface waters, and watercourses that are usually dry.

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OF SOUTH AUSTRALIA INCORPORATED

THE SIMPSON DESERT EXPEDITION, 1939
SCIENTIFIC REPORTS: No. 3, BIOLOGY—REPTILES AND BATRACHIANS

By J. R. Kinghorn, Australian Museum, Sydney

[Read 12 April 1945]

The reptiles and batrachians of Central Australia offer considerable interest for herpetologists because of their somewhat confusing distribution due to the nature of the country and the climatic conditions. Collections from this region are rarely large, collectors seldom have the opportunity to camp in any one locality for any length of time, and even if they do a sudden cool change sends reptiles to earth, where they remain hidden for many days in places where a white man has little chance of finding them. The Simpson Desert area would be no exception to this rule, for its chief characteristics are level plains, sandridges, an absence of surface waters, and watercourses that are usually dry.

Although the reptilian fauna was found to be much scarcer than in other parts of Central Australia, yet a collection of 120 specimens was made, comprising 18 different genera, included in which were 20 species of lizards, three species of snakes and one frog.

The caravan was almost continually on the move during daylight hours, coming to rest only at evening to camp, when most reptiles had retired for the night, and it is surprising that so many were seen and captured.

The biological collecting was in charge of Mr. H. O. Fletcher of the staff of the Australian Museum, Sydney, which institution provided the necessary equipment. All members of the expedition assisted, but, as might be expected, the most expert and untiring collector was an aborigine named Andy, a member of the Dieri tribe, who even while on the march could tell by glancing at a burrow whether a lizard was within it. Though Andy was very much afraid of the Scincidae, he was quite unafraid of snakes.

It is quite obvious that there were considerable difficulties regarding preservation, particularly in transport by camel, but even so the specimens arrived at the Museum in an excellent state of preservation, a fact that reflects credit on Mr. Fletcher.

The following is the complete list of the reptiles and batrachians collected.

AMPHIBIA

Fam. CERATOPHRIIDAE

Heliporus centralis Parker 1940

Heliporus pictus (non Peters) Spencer, 1896, Horn Exped. Central Australia, 2, Zool., 166, pl. xiii, fig. 2, pl. xiv, fig. 10-13.
Heliporus centralis Parker 1940, Novit. Zool., **42**, (1), 35.

A male collected on 27 June at Kaliduwarry Station, Camp 20, Mulligan River, near the Queensland border, measured 30 mm. in length; colour pale grey with darker mottlings and a faint, whitish vertebral line.

A female, 38 mm., of the same colour, but without the vertebral line, was found in a burrow three feet deep on top of a sandhill six miles north-west of Birdsville, on 6 July. The sand was damp, it having rained a little earlier in the day, and Andy, the aborigine, had detected the footprints of the frog.

In the Australian Museum are five other specimens; two of them taken by the Horn Expedition, and three from Central Australia were in the J. J. Fletcher collection. They measure from 40 mm. to 55 mm. in length.

LACERTILIA

Fam. GEKKONIDAE

NEPHURUS LAEVIS De Vis 1896

Nephurus laevis De Vis 1886, Proc. Linn. Soc. N.S.W., (2), **1**, 168; Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 296.

Found at Camp 3 on 8 June, six miles north of junction of the Todd and Hale Rivers, total length 541 mm., tail 30 mm.; and at Camp 19 on 27 June, total length 95 mm., tail 29 mm. Loveridge gives an excellent key by which the three species of this genus may easily be diagnosed. In this species the dorsal tubercles are large, conical, smooth, and each is surrounded by a ring of small granules.

LUCASIUS DAMAEUS (Lucas and Frost 1896)

Ceramodactylus damaeus Lucas and Frost 1896, Proc. Roy. Soc. Vict., (2), **8**, 1.
Lucasius damaeus Kinghorn 1929, Rec. Aust. Mus., **17**, (2), 77.

Four specimens of this exceptionally rare gecko were collected at Camp 6 on 17 June. One has its tail missing, but the others measure 47 mm., 49 mm. and 50 mm. in total length, by which it will be realised that they are not fully adult. A critical examination shows that there is no variation from the typical.

HETERONOTA BYNOEI Gray 1845

Heteronota bynoei Gray 1845, Cat. Liz. Brit. Mus., 174.

This species is very widely distributed throughout the northern parts of Australia, from Queensland to Western Australia. Specimens were collected under logs at Camp 34, five miles from Mount Gason; at Camp 37, Cowarie Station; and at Camp 40, along the Diamantina River, in South Australia.

DIPLODACTYLUS TESSELLATUS (Günther 1844)

Stenodactylus tessellatus Günther 1844, Zool. Erebus & Terror Rept., 16.
Diplodactylus tessellatus Blgs., 1885, Cat. Liz. Brit. Mus., **1**, 103, pl. viii, fig. 6; Kinghorn 1929, Rec. Aust. Mus., **17**, (2), 83.

One specimen from Camp 36, 12 miles north-east of Cowarie Station. Though nearly 100 specimens of this gecko were collected near Broken Hill, N.S.W., and on the Darling River during the 1890 floods, very few have been seen since, and it is generally regarded as one of the rarities, particularly in Central Australian areas. The Cowarie specimen measures 79 mm., of which the tail is 25 mm. It is noted that the larger tubercles of the tail are so arranged as to give a ringed appearance, the central pairs of tubercles having a smaller one on either side.

PEROPUS VARIEGATUS VARIEGATUS (Dumeril and Bibron 1836)

Hemidactylus variegatus D. and B. 1836, Erpet. Gen., **3**, 353.
Gehyra variegata Blgr., 1885, Cat. Liz. Brit. Mus., **1**, 151.
Peropus variegatus variegatus Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 311.

Twenty-eight specimens were collected, mostly under the loose bark of gidgee and mulga trees. Several were found on Andado Station: one, six miles north of the junction of the Todd and Hale Rivers; others at Camps 7, 8, 12, 16 (the Hay River), 21 (Kaliduwarry Station, Queensland), 22 (12 miles south of Annandale Station), 23, 24, 27 (Karrathunka Waterhole, 25 miles south of Birdsville, Queensland), 28, 32, and 40.

Fam. AGAMIDAE

AMPHIBOLURUS BARBATUS BARBATUS (Cuvier 1829)

Agama barbata Cuvier 1829, Regne Animal (2nd ed.), **2**, 35.
Amphibolurus barbatus Blgr., 1885, Cat. Liz. Brit. Mus., **1**, 391.
Amphibolurus barbatus barbatus Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 324.

This is one of the most widely distributed of the Australian Agamas, and is found in all kinds of country. Five specimens were collected on the Simpson Desert at the following Camps: No. 9, No 15 on the Hay River Flood Plain, and No. 19. They were taken in spinifex, sand and grassy country. Those from the sandy areas were brick-red in colour.

AMPHIBOLURUS PICTUS Peters 1867

Amphibolurus pictus Peters 1867, (1866), Monat. Akad. Wiss., Berlin, 88; Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 320.

Five specimens of this beautiful lizard were collected. Though fairly widely distributed in Central and South Australia it is nowhere common. It is most often to be found hiding under logs or large loose stones, and was secured at the following localities during the expedition: Camps 24, 40, 41 (north end of Lake Eyre), and Camp 49 (south end of Lake Eyre). The smallest specimen measures 97 mm., of which the tail is 60 mm., and the largest is 225 mm., tail 165 mm.

AMPHIBOLURUS RETICULATUS INERMIS (De Vis 1888)

Grammatophora inermis De Vis 1888 (1887), Proc. Linn. Soc. N.S.W., (2), **2**, 812.
Amphibolurus reticulatus inermis Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 321.

A valuable series of 25 specimens was collected throughout the desert area, and, though there is some variation in colour markings, the scalation and other characteristics are typical of *inermis*. The femoral and preanal pores range from 16 to 26, and the sizes range from 90 mm. to 260 mm., in total length. Eleven were found around Andado Station, three from the junction of the Todd and Hale Rivers, and the remainder from Camps 7, 9, 11, 13, 19, 23, 24, and 32 (Goyder's Lagoon).

AMPHIBOLURUS MACULATUS MACULATUS (Gray 1842)

Uromastyx maculatus Gray 1831, Cuvier, Animal Kingdom, **9**, syn., 62.
Amphibolurus maculatus Lucas and Frost 1896, Horn Sci. Exped. Rept., **2**, 125.
Amphibolurus maculatus maculatus Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 318.

This is probably the most brilliantly coloured species of the genus *Amphibolurus*. It inhabits sandy and sparsely timbered country, and with its red dorsal surface covered with yellow spots, and black markings on the flanks, is most conspicuous when lying in the open. One collected at Camp 7 on 17 June, total length 200 mm., tail 150 mm.; two from Camp 14, total length 100 mm., tail 66 mm.; two from Camp 16 on 24 June, total length 188 mm. and 200 mm., tails 130 mm. and 142 mm., respectively.

TYMPANOCRYPTIS CEPHALUS Günther 1867

Tympanocryptis cephalus Günther 1867, Ann. Mag. Nat. Hist., (3), **20**, 52. Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 325.
Tympanocryptis tetraporophora Lucas and Frost 1895, Proc. Roy. Soc. Vict., **7**, 265.
Tympanocryptis lineata cephalus Kinghorn, 1932, Rec. Aust. Mus., **18**, (7), 360.

Head shields only feebly keeled, nostril on a sharply defined canthus; snout somewhat sharper than in *lineata*. Dorsal surface with widely spaced, spinose tubercles. Colour greyish, with very indistinct cross bands which are broken on the central line. Only three specimens were collected from the following localities: Camp 31, Goyder's Lagoon Station, total length 140 mm., tail 80 mm.; Camp 49, Lake Eyre, total length 120 mm., tail 67 mm.; four miles east of Camp 49, total length 130 mm., tail 77 mm.

Tympanocryptis lineata lineata Peters 1864

Tympanocryptis lineata Peters 1864 (1863), Monat. Akad. Wiss., Berlin, 230.
Tympanocryptis lineata lineata Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 325.

Three specimens. The head shields and dorsal tubercles are strongly keeled; nostril below the canthus; snout rather obtuse; the head in each instance is shorter and deeper than in *cephalus*. One from near Camp 1, total length 124 mm., tail 94 mm.; one from Charlotte Waters, total length 180 mm., tail 64 mm.; one from four miles east of Camp 49, Lake Eyre, total length 91 mm., tail 55 mm.

Diporiphora australis (Steindachner 1867)

Calotella australis Steindachner 1867, Reise Oesterr. Freg. Novara, Reptiles, 29, pl. i, fig. 9.
Diporophora australis Blgr., 1885, Cat. Liz. Brit. Mus., **1**, 394; Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **22**, (6), 328.

Gular fold present. Two specimens were collected: one from Andado Station, Central Australia, total length 95 mm., tail 54 mm.; one from Camp 2, 22 miles north of Andado, total length 118 mm., tail 72 mm.

Moloch horridus Gray 1841

Moloch horridus Gray 1841, Gray's Journ. Exped. W. Aust., **2**, 441, pl. ii.

One specimen from Camp 19 on 27 June. It was seen during the trek to camp, and Andy, the aborigine, was afraid to touch it, but would not explain his fears. Total length 146 mm., tail 66 mm.

Fam. VARANIDAE

Varanus gilleni Lucas and Frost 1895

Varanus gilleni Lucas and Frost 1895, Proc. Roy. Soc. Vict., **7**, 266.

This rare and interesting goanna is restricted to the Northern Territory, Central Australia and the more northern parts of South Australia. One specimen, a male, was collected at Camp 16 on 24 June. Total length 285 mm., tail 170 mm.

It might be noted that in contrast to its nearest affinity *V. eremius*, the claws of *gilleni* are of normal length, strongly curved and deep at the base, while in *eremius* the claws are long, slightly curved and narrow throughout. The head scales of *gilleni* are six-sided and much more rounded than in *eremius*, in which they are elongate. The caudal scales in *gilleni* are feebly keeled and not so elongate as the strongly keeled scales of *eremius*.

Fam. SCINCIDAE

Egernia inornata Rosen 1905

Egernia inornata Rosen 1905, Ann. Mag. Nat. Hist., (7), **16**, 139, fig. 3, pl. vii, fig. 2; Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **77**, (6), 337.
Egernia striata Sternfeld, 1919, Senkenb. Naturf. Gesell., **1**, 79.

Three specimens were collected, and these differ slightly from the characters given by Loveridge in having fewer scales round the body, there being only 36 on each of the specimens. The frontal is twice as long as broad; six supra-oculars; one pair nuchals. One specimen from Camp 5 collected 8 June, total length 158 mm., tail 87 mm.; one from Camp 16, Hay River Flood Plain, on 24 June, total length 100 mm., tail 42 mm.; one from Camp 18 on 26 June, total length 127 mm., tail 62 mm.

Sphenomorphus australis australis (Gray 1839)

Tiliqua australis Gray 1839, Ann. Nat. Hist., **2**, 291.
Lygosoma lesueurii D. and B., 1839, Erpet. Gen., **5**, 733.
Sphenomorphus australis australis Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **77**, (6), 345.

Though this is a widely distributed species in Australia, and was found at the eastern and western edges of the Simpson Desert, it was not met with at any of the Camps in the central area. One specimen from Camp 2, 6 June, total length 94 mm.; and one from Camp 34, 18 July, near Mount Gason, total length 210 mm., tail 142 mm., 26 rows of scales, eye shorter than its distance from the nostril.

Sphenomorphus leae brooksi Loveridge 1933

Sphenomorphus leae brooksi Loveridge 1933, Occ. Papers, Boston Soc. Nat. Hist., **8**, 95.

Though the type of this subspecies was taken at Perth, Western Australia, I have no doubt that the seven specimens collected in the Simpson Desert are referable to *S. leae brooksi*. Mid body scale rows 26; the lamellae under the fourth toe are 26 in number and sharply keeled; auricular lobules 3, there being two large and one very small; nuchals 4; loreal scale longer than high; hind limb reaches the wrist or elbow; prefrontals forming a long median suture; the nasals may or may not just touch each other; frontal longer than interparietals and fronto-parietals together. Colour (in alcohol), greenish-grey with a strong metallic sheen; the markings on sides, limbs and tail are typical of those described by Loveridge.

In the Australian Museum collection is a specimen from Eucla, Great Australian Bight. The localities of those collected in the Simpson Desert are: Camp 2, 6 June; Camp 7, 12 June; Camp 10; Camp 11, 17 June; Camp 12; Camp 23, 9 July.

The distribution as plotted on the map is interesting, suggesting its dispersal throughout the desert area.

Ablepharus greyii (Gray 1844)

Menethia greyii Gray 1844, Zool. Erebus & Terror Rept., pl. v, fig. 4.
Ablepharus greyii Blgr., 1887, Cat. Liz. Brit. Mus., **3**, 349.

Two specimens from Camp 3, six miles north of the junction of the Todd and Hale Rivers, 8 June; two from Camp 28, Andrewilla Waterhole, 45 miles south of Birdsville, on 14 July. Mid body scales in 22 rows, digits 4, toes 5, average measurements—total length 77 mm., tail 47 mm.

Ablepharus boutoni metallicus Blgr. 1897

Ablepharus boutoni var. *metallicus* Blgr. 1887, Cat. Liz. Brit. Mus., **3**, 347.
Ablepharus boutoni australis Sternfeld, 1918, Abhand. Senkenb. Naturf. Gesell., **36**, 424.
Ablepharus boutoni metallicus Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **77**, (6), 375-376.

The species *boutoni* is a widely distributed one both in Australia and in Malaya, and is also extremely variable. The two specimens collected by the Simpson Desert Expedition have all the characteristics of *metallicus*, and are from Camp 28, Andrewilla Waterhole, 45 miles south of Birdsville, 14 July.

Rhodona bipes Fischer 1882

Rhodona bipes Fischer 1882, Arch. für Naturg., **48**, 292, pl. xvi, fig. 10-15.

This rare but widely distributed lizard has a very prominent shovel-shaped snout, which is hard and typical of burrowing forms. Its discovery in the centre of the Simpson Desert was quite unexpected. One from Camp 3, six miles north of the junction of the Todd and Hale Rivers, 8 June; one from Camp 9, on 17 June; one from Camp 34, near Mount Gason, 18 July. One specimen is without tail, the others measure 70 mm., tail 23 mm.; and 88 mm., tail 40 mm.

OPHIDIA

Fam. BOIDAE

Aspidiotes melanocephala ramsayi Macleay 1882

Aspidiotes ramsayi Macleay 1882, Proc. Linn. Soc. N.S.W., **6**, 813.
Aspidiotes melanocephalus ramsayi Loveridge, 1934, Bull. Mus. Comp. Zool., Harvard, **77**, (6), 270.

One specimen from Camp 17, Simpson Desert, total length 1,980 mm., tail 140 mm., male. Anal scale single; subcaudals 46, all single; ventrals 309. The frontal is almost square, and is twice as broad as the supraoculars; 56 scales round the centre of the body. The abnormality of the head shields is accentuated by the breaking up of the prefrontals and loreal into a number of small shields of different shapes and sizes.

Fam. COLUBRIDAE

Pseudechis australis Gray 1842

Pseudechis australis Gray 1842, Zool. Miscell., 55; Blgr., 1896, Cat. Snakes Brit. Mus., **3**, 330.

One specimen from Camp 12, total length 1,600 mm., tail 175 mm., tip missing; subcaudals 40 single (it being assumed that those on the missing tip were divided), anal divided, scales in 17 rows. The internasals are not half as large as the prefrontals. Frontal one-third longer than broad, a little broader than the supraocular, smaller than the prefrontals. The variations in the comparative sizes of the head shields are regarded as abnormalities.

I have since received several specimens from the northern parts of Central Australia with subcaudals mostly single, only a few near the tip of the tail being divided.

Demansia modesta Blgr. 1896

Demansia modesta Blgr. 1896, Cat. Snakes, Brit. Mus., **3**, 324.
Demansia modesta Kinghorn, 1929, Snakes of Australia, 130, fig. 72 (in colour).

Two specimens were collected at widely separated localities. In colour they are identical with that figured in "Snakes of Australia."

A specimen from Camp 1, eight miles north of Andado Bore No. 1, 4 January, measures 360 mm., of which the tail is 48 mm., scales 17; subcaudals 34, paired; the length of the rostral is two-thirds its distance from the frontal. Another was collected at Camp 17 on 25 June, total length 430 mm., tail 69 mm., scales 17, subcaudals 44, paired. Portion of rostral visible from above is equal to half its distance from the frontal.

This is a very variable species and has a wide distribution in Australia. It is also a very perplexing one, having close affinities to *Demansia textilis nuchalis*.

DISTRIBUTION OF SPECIES COLLECTED

Camps	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	31	32	33	34	36	37	40	41	49
Helioporus centralis																				x					x											
Nephurus laevis			x																x																	
Heteronota bynoei																															x		x	x		
Lucasius damaeus						x																														
Diplodactylus tessellatus																																x				
Peropus variegatus variegatus ..	x		x				x	x				x				x					x	x	x	x		x	x		x	x				x		
Diporiphora australis	x	x																																		
Tympanocryptis cephalus																												x								x
Tympanocryptis lineatus lineatus..	x																																			
Amphibolurus barbatus barbatus ..									x						x				x																	
Amphibol. reticulatus inermis ..	x		x				x		x		x		x		x				x				x	x												
Amphibol. pictus																								x										x	x	x
Amphibol. maculatus maculatus .						x								x		x																				
Moloch horridus																			x																	
Varanus gilleni																x																				
Egernia inornata					x											x		x																		
Sphenomorphus australis australis		x																													x					
Sphen. leae brooksi		x					x			x	x	x									x		x													
Rhodona bipes			x					x																							x					
Ablepharus greyii																											x									
Ablepharus boutoni metallicus ..																											x									
Aspidiotes melanocephalus ramsayi																	x																			
Pseudechis australis												x																								
Demansia modesta	x																x																			
																	x	x																		

THE SIMPSON DESERT EXPEDITION, 1939 SCIENTIFIC REPORTS: NO. 5, BIOLOGY - FISHES

BY G. P. WHITLEY, F.R.Z.S., AUSTRALIAN MUSEUM, SYDNEY (READ 12 APRIL 1945)

Summary

The only surface waters met with by the Expedition other than the very temporary and shallow water of claypans, was in waterholes in the Coglin Creek and Charlotte Waters, Northern Territory, and in the Diamantina River. Even the Coglin Creek waterholes may be quite dry for long periods, but they contained clear shallow water in May, 1939, when small fish could be seen and six specimens were netted by Mr. H. O. Fletcher. No attempt was made to take fish in the Diamantina except at Andrewilla Waterhole in South Australia, 45 miles below Birdsville, and at its end near Lake Eyre. Hand lines were used at both places. Andrewilla is a large permanent hole, and several perch were caught there up to half-a-pound in weight. The water was white with suspended clay and the fish were of a curious paleness, a sort of opalescent white. However, as they were good eating and it was thought they would prove to be a well-known species, only the smallest was put into the spirit bottle. The water at the mouth of the river was slightly brackish, and there were no bites on the hand lines. Although the Diamantina runs a channel flood every year, only certain waterholes are permanent. – C. T. Madigan

THE SIMPSON DESERT EXPEDITION, 1939
SCIENTIFIC REPORTS: No. 5 BIOLOGY — FISHES

By G. P. WHITLEY, F.R.Z.S., Australian Museum, Sydney

[Read 12 April 1945]

[The only surface waters met with by the Expedition other than the very temporary and shallow water of claypans, was in waterholes in the Coglin Creek and Charlotte Waters, Northern Territory, and in the Diamantina River. Even the Coglin Creek waterholes may be quite dry for long periods, but they contained clear shallow water in May, 1939, when small fish could be seen and six specimens were netted by Mr. H. O. Fletcher. No attempt was made to take fish in the Diamantina except at Andrewilla Waterhole in South Australia, 45 miles below Birdsville, and at its end near Lake Eyre. Hand lines were used at both places. Andrewilla is a large permanent hole, and several perch were caught there up to half-a-pound in weight. The water was white with suspended clay and the fish were of a curious paleness, a sort of opalescent white. However, as they were good eating and it was thought they would prove to be a well-known species, only the smallest was put into the spirit bottle. The water at the mouth of the river was slightly brackish, and there were no bites on the hand lines. Although the Diamantina runs a channel flood every year, only certain waterholes are permanent. —C. T. Madigan.]

I am grateful to Dr. C. T. Madigan for the privilege of writing this report on the fishes taken by the Simpson Desert Expedition. These comprise seven small specimens referable to three species, two in the family Terapontidae and one in the Chandidae.

Fam. TERAPONTIDAE

The local species of *Terapon* have been reviewed by Ogilby and McCulloch (1916) in Memoirs of the Queensland Museum, 1916, **5**, 99-126. The Australian forms were again listed in Mem. Aust. Mus., 1929, **5**, 159-164. Since then Fowler has dealt with numerous species in Bull. 100, U.S. Nat. Mus., 1931, **11**, 325-358. In the same year, Weber and de Beaufort (Fish Indo-Austr. Archip., 1931, **6**, 139-159), monographed the East Indian species. Some new genera were named in Austr. Zool., 1943, **10**, 180-184, and a few new species have been described from newly explored regions.

Two species, both known to science, were collected by the Simpson Desert Expedition, one now referable to *Hephaestus* De Vis, whilst the other requires a new genus, which may be defined as follows.

Genus **Madigania** nov.

Orthotype, *Therapon unicolor* Günther 1859.

Mouth large, reaching below middle of the small eye. Teeth villiform on jaws, outer ones enlarged; palate toothless. Preorbital entire or with a few denticles. Lower opercular spine not reaching gill-opening. Body elongate-elliptical. Supracleithrum not exposed, hidden by scales. Less than 60 rows of lateral scales: 8 or 9 between l. lat. and spinous dorsal. Normally 12 dorsal spines. General characters as for the family Terapontidae. Colouration greyish, usually with small scattered dark spots. No dark blotch on spinous dorsal, no stripes on body. Caudal fin plain. Freshwater, tropical and subtropical Australia.

Differs from the true marine *Terapon*, in having long, low, first dorsal fin, without dark blotch; body not silvery with stripes, lower opercular spine much shorter, and caudal fin emarginate.

Named in honour of Dr. Cecil Madigan, leader of the Expedition.

Madigania unicolor (Günther 1859)

Therapon unicolor Günther 1859, Cat. Fish. Brit. Mus., **1**, 277 (Gwydir River, N.S.W., and Mosquito Creek, Darling Downs, Qld.; types in British Museum); Ogilby and McCulloch, 1916, Mem. Qld. Mus., **5**, 101, 109, pl. xi, fig. 1 (detailed description, references and synonymy); Rendahl, 1921, K. Svenska Vet. Handl., **61**, 9 (Noonkambah, Kimberley District, North-West Australia), and 1922, Medd. Zool. Mus., Kristiania, **5**, 166 and 185 (Port Darwin and Daly River, North-West Australia); Paradice and Whitley, 1927, Mem. Qld. Mus., **9**, 88 (Howard River, Northern Territory); Hamlyn-Harris, Proc. Roy. Soc. Qld., **41**, 1929, 34 (north of Mary River, Qld.); Fowler, 1931, Bull. U.S. Nat. Mus. 100, **11**, 355 (Bourke, N.S.W.); Marshall and Preston, 1934, 30th Ann. Rept. Amat. Fisherm. Assoc., Qld., 4 (Mary River, Qld.); Fletcher, 1937, Aust. Mus. Mag., **6**, (5), 164 (Waroona Creek, Qld.); Toronese, 1939, Bull. Mus. Torino, **47**, 187, 300 ("Melbourne," *i.e.*, from National Museum there).

Therapon maculosus Saville-Kent 1893, Great Barrier Reef, 369, *nom. nud.*, Queensland.

Therapon (Mesopristes) unicolor Fowler, 1928, Mem. Bishop. Mus., **10**, **211**.

Leiopotherapon unicolor Barrett, 1933, Water Life, 13.

This species has been so fully dealt with by Ogilby and McCulloch that it only remains to add references to records in recent literature and to list localities at which it has been taken.

The Simpson Desert Expedition obtained five examples, 27·5 to 77 mm. in standard length at Coglin Creek, Charlotte Waters, Northern Territory. Abundant, swimming swiftly in small creeks.

Collector's No. 501; Aust. Mus. Reg. Nos. IB. 22 to 26.

Apart from the material collected by the Simpson Desert Expedition, the Australian Museum has many specimens of *Madigania unicolor,* up to 9½ inches long, from the following localities:—

Western Australia: King Sound (J. Cairn); Paterson Ranges, Kimberley District (H. Basedow); Gascoyne River and Kimberley (W. Aust. Museum); Murgoo, north-west-north of Yalgoo, northern goldfields railway line, "Many thousands of these fish were found alive scattered over a large area of country after a very heavy north-west storm had passed over. The fish appeared to have come down with the rain. There is no known water here" (Gibson, 1925, MS.).

Northern Territory: Inland from Port Darwin (Wm. Butcher); Howard River, 35 miles east of Darwin (W. E. J. Paradice); Red Bank Creek, Macdonnell Ranges, Indracowra, Central Australia (W. Horn).

Queensland: Winton (Qld. Museum); Flinders River and adjacent pools near Hughenden and Richmond (F. L. Berney); Hughenden district (G. C. Currie); Split Rock, Waroora Creek, 30 miles from Camooweal (H. O. Fletcher and W. Barnes); Lake Barrine, Atherton Tableland (G. Curry); Almaden (W. D. Campbell); Gayndah (Old Coll.); Billabongs of the Diamantina River (S. W. Jackson); Burdekin River; Lillesmere Lagoons (A. Morton); Rockhampton (Nobbs); Eidsvold, Burnett River (T. L. Bancroft). New record size 9½ inches.

New South Wales—Barwon River and Tarrion Creek, Brewarrina, Aug. 1910 (D. G. Stead); Bourke (Cairn, Grant and Shaw); Moree (Barnes and Lucas); Warrah Creek, Willowtree, near Quirindi; Liverpool Plains (G. Fairbairn), southernmost record; Walgett (artesian water, hospital grounds, May 1910, D. G. Stead); Wirrabilla Station, Collarenebri (D. G. Stead); Weil-

moringle Bore, from drains, July 1908 (D. G. Stead); Beringaga (D. G. Stead); Corella Bore, (a "pop-eyed" specimen from D. G. Stead).

This range agrees with that given by Ogilby and McCulloch for the species. The wide distribution may be attributed to the hardihood of the fish, its ability to aestivate out of water, and, perhaps, such fortuitous agents as rain, rare floods, carriage of eggs by waterfowl, etc. Essentially it inhabits the Leichhardtian fluvifaunula.

Genus Hephaestus De Vis

Hephaestus welchi (McCulloch and Waite 1917)

Therapon welchi McCulloch and Waite, 1917, Trans. Roy Soc. S. Aust., **41**, **472**, fig. 1 (Cooper Creek, near Innamincka, Central Australia); Waite, 1921, Rec. S. Aust. Mus., **2**, (1), 97; 1923, Waite, Fish. S. Aust., 117 and 119.

The single specimen has, unfortunately, been damaged during camel transport, so that the snout is crushed, the caudal fin broken off, and some fin-rays and scales abraded.

D. xii, 12; A. iii, 9; P. 17; V. i, 5; C ?.

Sixty rows of scales below the lateral line between its origin and the hypural joint, and 64 above it. Ten to 13 scales between lateral line and spinous dorsal fin. Cheek scales in five to seven rows.

Depth (44 mm.) 3, head (39) nearly 3·5 in length to hypural joint (136). Eye (7) 5·5 in head, 3 in postorbital (21), and a little less than snout. Interorbital width (11·5) nearly 3·4 in head.

Longest (fifth) dorsal spine (19) and second anal spine (20) about half length of head.

General characters as described by McCulloch and Waite. Maxillary reaching at least to below hinder nostril or to anterior half of eye, its posterior margin obliquely truncate and exposed. Eye slightly shorter than snout (damaged), which may be shorter than interorbital width, otherwise the head and dentition appear typical. Supracleithrum and cleithrum exposed, weakly denticulate. Lower opercular spine barely reaching opercular margin. Dorsal spines heteracanth, the fifth longest. Second anal spine longer and stronger than the third. The anal and pectoral rays are broken. Ventrals inserted *behind* the vertical of first dorsal spine and reaching half its distance to the anal fin.

Colour, in alcohol, greyish to brownish on back, silvery on sides with dark margins on scales. Fin-membranes and root of tail dusky grey, fin-spines olive-greenish. Groups of scattered chromatophores under each scale on sides give, from a distance, an appearance of wavy stripes along scale-rows. No dark blotches on fins.

Described from a specimen 136 mm. in standard length, originally probably about 6½ inches overall.

Loc.—Andrewilla Waterhole, South Australia, 45 miles south of Birdsville. Camp No. 28. One of several specimens observed at the time (Sturtian fluvifaunula). Collector's No. 637, Aust. Mus. Reg. No. IB. 21. New to the Australian Museum collection because this species was hitherto known only from the type, over eight inches long, caught with hook and line in Cooper Creek near Innamincka in 1916, close to the spot where Burke was buried, and preserved in the South Australian Museum, Adelaide.

Dr. Madigan's specimen differs in the proportions of the eye (and its surrounding parts) to the head and in having the ventral fins farther back, but I think these differences are accounted for by heterogonic variation.

Fam. CHANDIDAE

Small, almost transparent perch-like fishes, found commonly in shoals in fresh and salt water, with compressed bodies covered with large cycloid scales. Ventral fins usually without tapering axillary scale. Frontals with muciferous channels. Preoperculum with a double ridge, the lower limb of which is serrated. Mouth small, no supplemental bone on maxillary. Body compressed, not very deep. Lateral line practically obsolete, only a few scales bearing tubes. Dorsal and anal spines not very strong. About eight dorsal and anal rays.

BLANDOWSKIELLA CASTELNAUI (Macleay 1881)

Pseudoambassis castelnaui Macleay 3 Feb. 1881, Proc. Linn. Soc. N.S.W., **5**, 339; Macleay 1881, Cat. Aust. Fish., **1**, 39. Murrumbidgee River, N.S.W.

Chanda castelnaui Waite, 1904, Mem. N.S.W. Nat. Club, **1**, 29.

Ambassis castelnaui McCulloch, 1921, Aust. Zool., **2**, (2), 55, and of check-lists.

Blandowskiella castelnaui Iredale and Whitley, 1932, Vict. Nat., **49**, 95; Whitley, 1935, Rec. S. Aust. Mus., **5**, (3), 361, fig. 9 (Narrandera specimen figured).

The Simpson Desert Expedition obtained one small specimen, 20 mm. in standard length, with the following characters:

D. viii/i, 8; A. iii, 8. Most of the scales are missing but there are apparently 25 along the sides, only the anterior few bearing lateral line tubes. L. tr. *circa* 12.

Eye (2·4 mm.) about 3, snout (1·5) about 4 in head (7·5).

Depth (7) and head about one-third standard length.

Supraorbital raised into a point (hardly a spine) posteriorly.

Agrees well with my figure of a New South Wales specimen, but is a little deeper between soft dorsal and anal fins and has slightly shorter snout. Straw-yellowish with punctae on back and fins. Membranes between first two dorsal spines punctulate. A dark streak along middle of caudal peduncle.

Loc.—Coglin Creek, Charlotte Waters, Northern Territory. Collector's No. 501, pt. Aust. Mus. Reg. No. I.B. 27.

This species grows to a length of 3¼ inches and inhabits the Mitchellian fluvifaunula. This is the first record of this species from South Australia and the Northern Territory.

Fifty-seven specimens of *Blandowskiella castelnaui* are in the Australian Museum from:

New South Wales—North Yanco, Narrandera, N.S.W., January 1910 (D. G. Stead); tributaries of the Lachlan River, Goulburn, N.S.W. (A. C. Gibson); Wirrabilla Station, Collarenebri (D. G. Stead); Colombo Creek, Riverina, March 1910 (D. G. Stead); junction of the Barwon and Namoi Rivers, May 1910 (D. G. Stead).

South Australia—Hart's Island, Murray River, May 1903 (D. G. Stead). "Easily observed when water is clear. Very abundant, keep low, near bottom (Stewart)."

The Simpson Desert Expedition material is of interest because it includes, in its Sturtian region, *Madigania*, which, though essentially Leichhardtian, is widely distributed through several northern fluvifaunulae, *Hephaestus* (*welchi*), which is Sturtian with Jardinean affinities, and *Blandowskiella*, which is Mitchellian. (See Iredale and Whitley, 1938, S. Aust. Naturalist, **18**, 64-68.)

THE SIMPSON DESERT EXPEDITION, 1939 SCIENTIFIC REPORTS: NO. 4 BIOLOGY - HEMIPTERA

BY A. MUSGRAVE, AUSTRALIAN MUSEUM, SYDNEY (READ 12 APRIL 1945)

Summary

The Hemiptera-Heteroptera collected by Mr. H. O. Fletcher of the Australian Museum and members of Dr. C. T. Madigan's Simpson Desert Expedition into Central Australia, have been handed to me for determination. The collection comprises some 18 specimens.

THE SIMPSON DESERT EXPEDITION, 1939
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[Read 12 April 1945]

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Fam. PENTATOMIDAE

Eumecopus y-nigrum Bergroth 1916

Eumecopus y-nigrum Bergroth 1916, Proc. Roy. Soc. Vict., (n.s.) 29, (1), 21. Central Australia. ♂ ♀.

Hay River, near Queensland border, Camp 16, 1 ♀ ; Finke River, Central Australia, 4 June 1939, 2 ♀ ♀ ; and 4 immature specimens, Finke River, 28 May and 4 June 1939, from *Eucalyptus microtheca,* are apparently referable to this species.

Poecilometis borealis Distant 1910

Poecilometis borealis Distant 1910, Ann. Mag. Nat. Hist., (8), 6, 380. Alexandria, Northern Australia.

Burts Waterhole, South Australia, 55 miles south of Birdsville, Camp 39, 1 ♂.

Kapunda typica Distant 1911

Kapunda typica Distant 1911, Ann. Mag. Nat. Hist., (8), 7, 342. Sydney, N.S.W.

Andado Station, 29 May 1939, 1 ♀.

Genus Ochisme Kirkaldy 1904

Trachyops Dallas 1851, List Hem. Ins. B.M., 1, 151 and 187.

Ochisme Kirkaldy 1904, Entom., 37, 280. New name for *Trachyops,* preoccupied.

Hypolcus Bergroth, 1916, Proc. Roy. Soc. Vict., (n.s.) 29, (1), 26. Haplotype: *H. apricus* Bergroth.

Ochisme australis (Dallas)

Trachyops australis Dallas 1851, List Hem. Ins. B. M., 1, 188, pl. vii, fig. 1.

Hypolcus apricus Bergroth 1916, Proc. Roy. Soc. Vict., (n.s.), 29, (1), 27.

Andado Station, Central Australia, 29 May 1939, 1 ♀. This species seems to have been lost sight of since Dallas described it in 1851, probably owing to the fact that it is an inland species, and the majority of collectors in the past have confined their attentions to the coastal areas of the continent. *Hypolcus apricus* Bergroth, appears to be synonymous with it.

Fam. COREIDAE

Mictis profana (Fabricius 1811)

Lygaeus profanus Fabr. 1811, Syst. Rhyn., 211, 33, Amboina.

Mictis profana Lethierry and Severin, 1894, Cat. Hem., 2, 9. For synonymy.

Camp 13, 24 miles west of Hay River, Simpson Desert, Central Australia, 1 ♀ ; 12 miles north-west of Birdsville, Queensland, 1 ♀.

Fam. LYGAEIDAE

Lygaeus mactans Stål 1886

Lygaeus mactans Stål, 1886, Berlin Ent. Zeitschr., **10,** 162. North Australia; Sydney; Fiji.

Six miles north of Todd and Hale River junction, Simpson Desert, Camp 3, 1 ♀. A widely distributed species occurring in North Australia, South Australia, Queensland, and western New South Wales.

Dieuches notatus (Dallas 1852)

Rhyparochromus notatus Dallas, 1852, List Spec. Hem. Ins. B.M., **2,** 569, n. 26. New South Wales; Tasmania.

Dieuches notatus Stål, 1873, K. Sv. Vet. Akad. Handl., **12,** (1), 161, n. 6. Melbourne; Tasmania.

Indinda Well, three miles west of Andado Station, Central Australia, 1 ♂.

Fam. REDUVIIDAE

Havinthus rufovarius Bergroth 1894

Havinthus longiceps Stål, 1881, var. B, Reuter, Act. Soc. Sc. Fennica, **12,** 23, n. 291.

Havinthus rufovarius Bergroth, Proc. R. Soc. Vict., (n.s.), **7,** 1894 (1895), 299. Western Australia. ♀.

Six miles north of Todd and Hale River junction, Simpson Desert, Camp 3. ♂.

Pirates near fulvipennis Walker 1873

Pirates fulvipennis Walker 1873, Cat. Hem. Heter., **7,** 128, n. 108, ♂. Melbourne; Australia.

Twenty miles west of Hay River, ♀. Specimen identified as above by Mr. W. E. China of the British Museum (Natural History).

Coranus near granosus Stål 1873

Coranus granosus Stål 1873, K. Sv. Vet. Akad. Handl., **12,** (1), 20, n.n. Australia.

Five miles west of Cowarie Station, Camp 38, ♀. Specimen identified by Mr. W. E. China.

THE RELATION OF WET-SEASON VARIABILITY TO FAT-LAMB PRODUCTION IN SOUTH AUSTRALIA

BY H. C. TRUMBLE, WAITE AGRICULTURAL RESEARCH INSTITUTE
(READ 12 APRIL 1945)

Summary

The fat-lamb production of different districts in South Australia has been investigated by Thompson (1), following a technical resolution (loc. Cit.) that climatological and statistical surveys were necessary to define the areas suitable and marginal for lamb-breeding.
The present contribution relates to Thompson's data the percentage occurrence of seasons considered favourable for the raising of lambs on pasturage only; that is to say, in the absence of hand-feeding.
The seasonal relationship between length of day, temperature, rainfall and evaporation was shown earlier to govern the type of agriculture practised in South Australia (2); and agro-climatic zones were established for Southern Australia (3) on the basis of the mean length of the rainfall season and the mean monthly temperatures for the three coldest months.
Following the emergency of natural climatic zones from the approach adopted, variability was examined; and the probabilities with which rainfall seasons of varying lengths, and varying amounts of influential rainfall could be expected to occur, were determined by Wark (4).

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By H. C. TRUMBLE, Waite Agricultural Research Institute

[Read 12 April 1945]

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METHODS

The growth of pasture in a single season is governed by a complex of factors, including the type of pasture, soil fertility, length of day and temperature, in addition to the duration of the period over which sufficient moisture is available; but it has been considered appropriate at this stage to deal specifically with moisture as the most critical of the uncontrollable limiting factors concerned.

The criterion adopted has been the maximum expected occurrence of an effective wet period of (a) 4 months, (b) 5 months, the former being regarded as the minimum time over which green grass should be available, and the longer period as a safer limit. As the time at which lambs are dropped is pre-determined by the date of mating, which tends to remain a fairly constant factor, the effective period may not occur at any time in the year, but must always date from the same month. A monthly critical limiting value of $\frac{R}{E} = 0{\cdot}3$ has been employed as in the previous work, the determinations of the periods being non-graphical.

Winter temperatures in South Australia are sufficiently high to permit active growth throughout the rainfall season, although there is undoubtedly enough variation to cause significant local differences in the rate at which feed is produced. The modifying effects of temperature and other factors can most properly be assessed after the position concerning the duration of available moisture and its variability has been defined.

In the author's previous analysis (1), the mean length of the period of influential rainfall was found to be closely related to the mean annual rainfall, provided distinct climatic zones were treated separately.

In the present study the mean length of this period has been related to the maximum expected occurrence of effective periods of 4 and 5 months, in each case dating from the first month for which the highest values obtain. The relationships, which follow closely an empirically determined parabolic form, have been employed to calculate the expectancies of these periods for South Australia.

Results of Analysis

The following table provides, in the case of the 20 centres for which sufficient data are available, the observed and calculated frequencies with which periods of 4 and 5 months, as defined above, have occurred. The observed values are those recorded by Wark (*loc. cit.*); the calculated values have been derived from curvilinear regression of the observed frequencies on corresponding values for the mean length of the effective rainfall season. In both cases the linear (b) and quadratic (c) coefficients are significant, with multiple correlations of 0·9462 (1) and 0·9804 (1) for 4 months and 5 months periods respectively.

The addition of influential rainfall as an independent variate in the multiple regression equation offered no advantages owing to its high correlation with length of rainfall season.

Table I

Mean annual rainfall, length of rainfall season and influential rainfall; observed and calculated frequencies of effective rainfall periods of (a) 4 months, (b) 5 months, dating from the month from which maximum values commence, for 20 centres in South Australia.

Centre	Mean annual rainfall (ins.)	Mean length of rainfall season (months) x_1	Mean influential rainfall (ins.) x_2	% 4 months periods obs. y_1	% 4 months periods calc. Y_1	% 5 months periods obs. y_2	% 5 months periods calc. Y_2
Mount Gambier	30·14	9·6	27·26	98	100	98	102
Mount Barker	31·03	8·4	27·24	98	95	92	90
Robe	24·75	8·3	21·35	96	94	94	89
Clare	24·41	7·7	20·12	90	88	84	80
Bordertown	19·25	7·4	15·01	82	85	72	74
Waite Institute	24·38	7·2	19·50	87	82	73	70
Kapunda	19·73	7·2	15·20	78	82	68	70
Kingscote	19·32	7·1	15·72	92	81	73	68
Port Lincoln	19·29	7·1	15·89	87	81	67	68
Strathalbyn	19·40	7·0	14·85	80	80	66	66
Maitland	19·85	7·0	15·15	74	80	61	66
Roseworthy College ..	17·38	6·8	13·14	68	77	55	62
Snowtown	15·76	6·3	11·30	64	68	55	50
Yongala	14·32	6·3	9·50	56	68	48	50
Lameroo	15·54	6·2	10·74	60	66	48	48
Streaky Bay	15·01	5·8	11·20	71	59	35	37
Kyancutta	13·49	5·3	8·10	55	48	22	23
Fowler's Bay	11·98	5·1	8·04	50	43	17	17
Port Pirie	13·27	4·9	7·07	39	38	5	11
Berri	10·13	4·6	4·82	21	30	7	1

Correlation coefficient $x_1 x_2$	Multiple correlation $y_1 x_1 x_2$	Partial correlations $x_1 y_1$ (elim. x_2)	Partial correlations $x_2 y_1$ (elim. x_1)
0·9555 (1)	0·9176 (1)	0·3812	0·2672

The constants for the two fitted regression equations, with their appropriate standard deviations, are as follows:

$$(Y = a + bx + cx^2)$$

	a	b	c
(1) 4 months periods (Y_1)—			
Value of term	$-145·3442$	$+49·7740$	$-2·5198$
S.D.	38·7054	11·1837	·8080
(2) 5 months periods (Y_2)—			
Value of term	$-211·0145$	$+58·2880$	$-2·6727$
S.D.	22·5984	6·5297	·4716

The standard deviations are fairly high, as only 20 pairs of relevant observations are available for comparison. In practice, however, there is much interdependence, and the calculated values are in sufficiently close agreement with the observed, as indicated in Table I.

(1) Significant at 1%.

The calculated values for 227 stations in South Australia, for which the mean rainfall season had previously been determined, have been employed to construct the maps shown in fig. 1 and 2. On the first of these, the lambs disposed of in 1939, as revealed by Thompson, are also indicated.

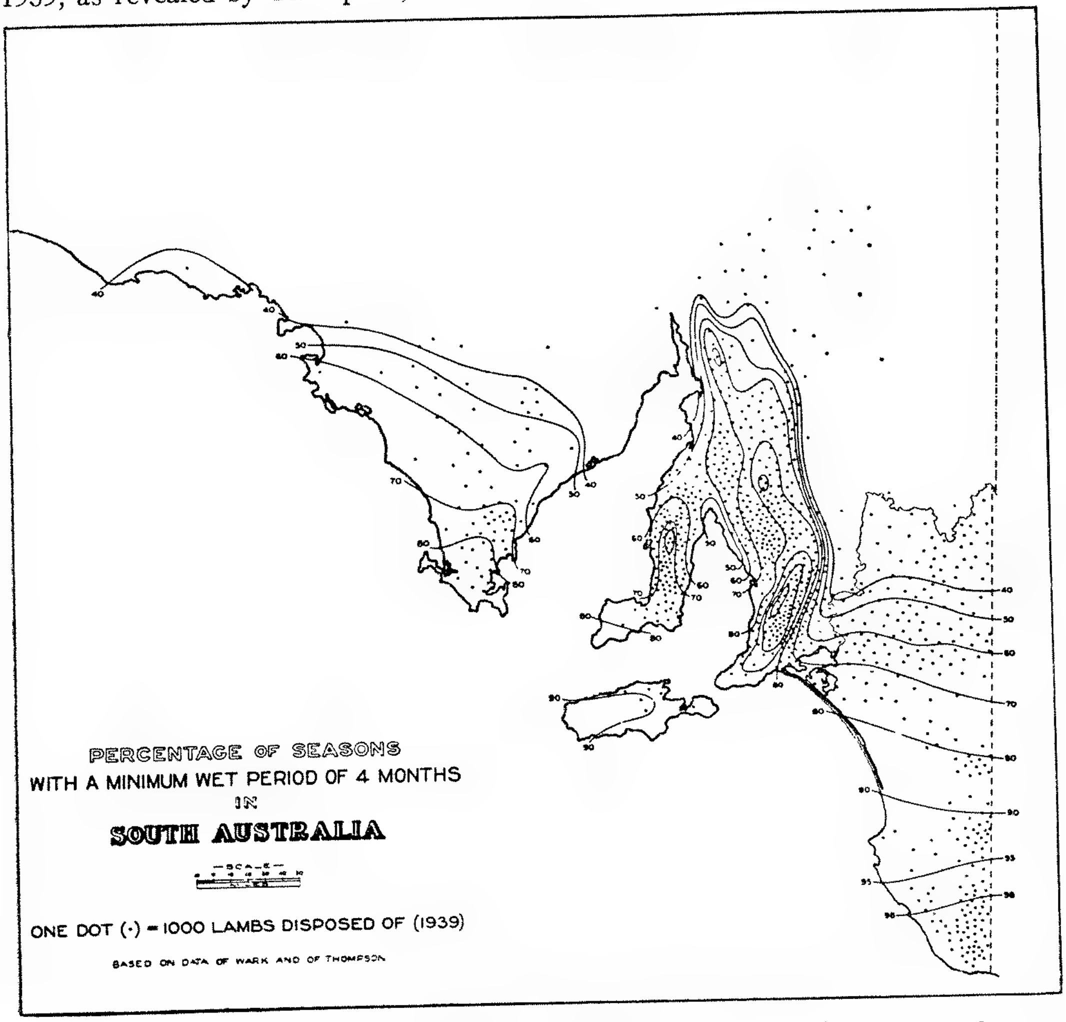

Fig. 1 Distribution of fat lambs (1939) in relation to the percentage occurrence of 4 months seasons.

In Table II, the location of the lambs according to the different zones of wet season frequency is given.

TABLE II

Location of lambs disposed of [2] in 1939 (in 1,000's) according to the frequency of 4 months wet periods

(% occurrence of 4 months periods)

District	98	95–98	90–95	80–90	70–80	60–70	50–60	40–50	40	Total
Central	8	42	32	80	134	65	14	6	5	386
Lower North	—	—	3	16	49	81	31	5	3	188
Upper North	—	—	—	1	9	6	2	2	27	47
South-East	49	17	29	15	7	—	—	—	—	117
Western	—	—	—	13	21	14	13	9	7	77
Murray Mallee	—	—	—	—	18	28	36	15	41	138
Totals for State ..	57	59	64	125	238	194	96	37	83	953

[2] Lambs "disposed of" represent the difference between lambs marked and those less than one year old at the end of each year. The figures thus include deaths and local slaughterings, as well as the numbers marketed as fat lambs.

The table, taken in conjunction with table IV and fig. 1 and 2, indicates the outstanding climatic advantages of the Central and South-Eastern districts, and their capacity for future development; current low numbers at the high rainfall probabilities are due to soil deficiencies, which can be and are being remedied.

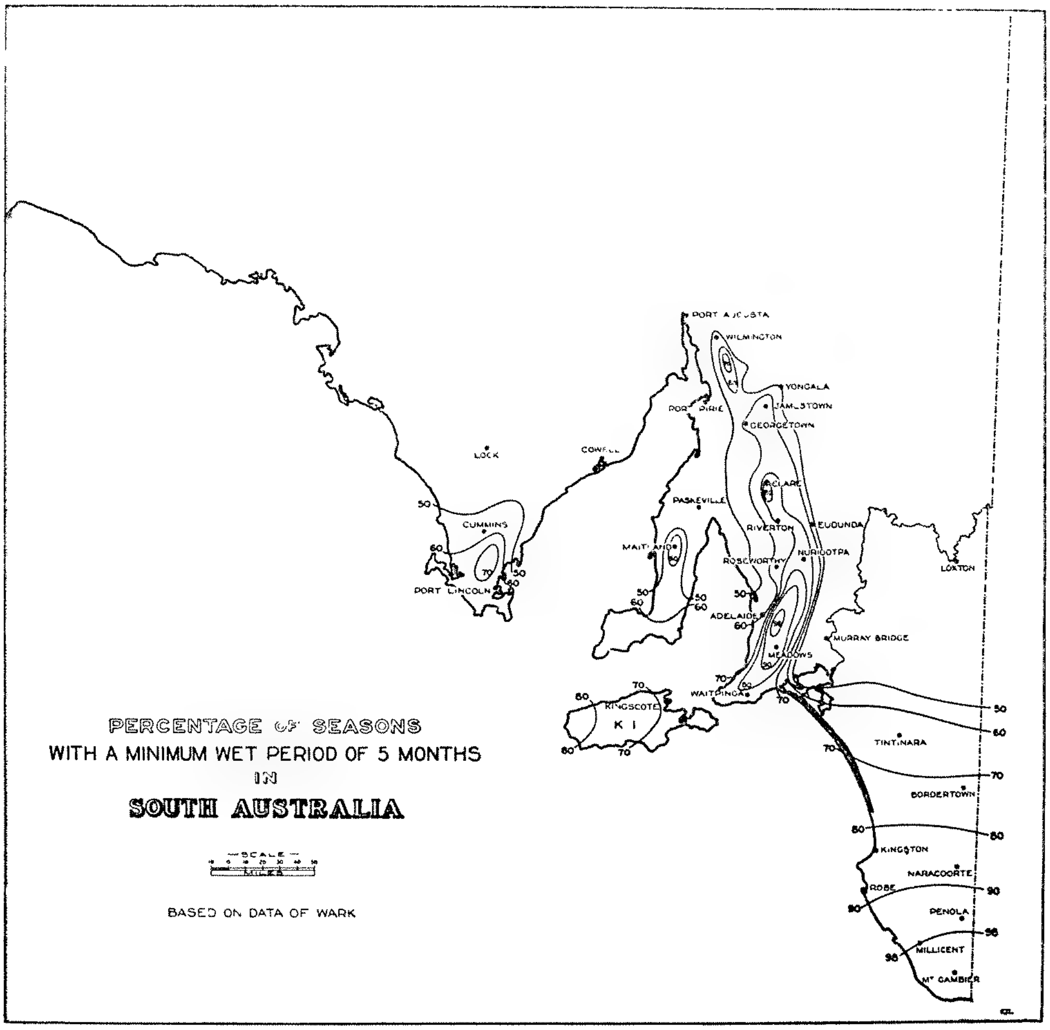

Fig. 2 Percentage occurrence of 5 months seasons, with location of key centres shown.

There are two qualifications to be considered in respect to Thompson's data, namely, that the numbers of lambs "disposed of" include deaths between marking and the end of each year, as well as those sold or slaughtered, and also that the figures apply only to the season 1939.

In regard to the first, no alternative means is available by which to arrive at the distribution of fat lambs; and, as Thompson has stated, the figures used indicate with reasonable accuracy the regional production of surplus lambs.

In regard to the second, the 1939 season was not characterised by any extreme climatic conditions and also represents the position better than earlier seasons, during which the industry was developing, or the succeeding seasons when the impact of war was felt.

The areas of greatest interest are the Central, South-Eastern, Mallee and Western districts, and the lambs disposed of over the seasons 1935-43 inclusive are given for these districts in table III.

TABLE III

Lambs disposed of (1000's) in four main districts of South Australia, 1935-43

	1935	1936	1937	1938	1939	1940	1941	1942	1943
Central	164	209	187	304	386	341	346	332	317
South-East	36	39	53	98	117	120	159	177	141
Murray Mallee .	70	63	64	102	138	137	132	137	124
Western	42	73	41	93	77	111	86	58	80

This table exhibits an interesting trend in the South-East, where the numbers have quadrupled since 1935-36, whereas in the Central and Mallee districts they have barely doubled, and in the Western area the slight increase is by no means a definite one. The trends are in line with the expectation to be drawn from the climatic analysis given, except in the case of the Murray Mallee, where the numbers themselves and the extent of their increase are both unexpectedly high. South-Eastern numbers, which remained below those for the Murray Mallee between 1935 and 1940 have substantially exceeded them in the three succeeding years, 1941-43.

Despite the figures for the Murray Mallee, this area cannot be regarded as suitable for the reliable production of fat lambs; and as pointed out by Thompson (*loc. cit.*), even the most favoured portions of this region must be regarded as marginal and better suited to half-bred ewe production than to fat lamb production.

Reference to table II indicates that 50% of the lambs disposed of in 1939 were located in areas where the percentage occurrence of favourable seasons is between 60 and 80.

The main concentration in this category is to the north-west of Adelaide, including the Gawler–Roseworthy–Owen area and much of Yorke Peninsula. In 20-40% of seasons in this region, however, hand-feeding is probably essential to attain continuity of high quality production.

The areas in South Australia receiving the frequencies of 4 months periods indicated are as follows:

TABLE IV

Areas of South Australia with varying frequencies of 4 months wet periods, dating from the month for which the frequency is maximum (square miles)

Frequency of 4 Month Seasons	>98	95–98	90–95	80–90	70–80	60–70	50–60	Total >50%
Kangaroo Island	—	—	910	790	—	—	—	1,700
Mount Lofty Ranges and adjoining Areas	70	490	660	1,800	3,200	2,740	2,470[3]	11,430
Yorke Peninsula	—	—	—	250	1,100	720	—	2,070
Eyre Peninsula & Western	—	—	—	1,100	1,130	4,620	3,740	10,590
South-East (incl. Lower Murray Mallee)	1,380	1,170	2,510	2,610	3,190	2,040[4]	1,850[4]	14,750
Total	1,450	1,660	4,080	6,550	8,620	10,120	8,060	40,540

Area with frequency > 90%

Total	South-East		Kangaroo Island		Mount Lofty Ranges	
sq. miles	sq. miles	% of Total	sq. miles	% of Total	sq. miles	% of Total
7,190	5,060	70·4	910	12·7	1,220	16·9

Area with frequency of 70-90%

Total	South-East		Eyre Pen., Yorke Pen., and Kangaroo Island		Mount Lofty Ranges and elevated Region to North	
sq. miles	sq. miles	% of Total	sq. miles	% of Total	sq. miles	% of Total
15,170	5,800	38·2	4,370	28·8	5,000	33·0

[3] Central and upper Yorke Peninsula combined. [4] Lower Murray Mallee.

The importance in South Australia of (a) taking advantage of the more assured climatic conditions of such areas as the South-East, the Mount Lofty Ranges and Kangaroo Island by improving soil fertility, and (b) making provision for the drought years that will inevitably occur in the cereal-growing areas, by the constant maintenance of fodder reserves, is clearly demonstrated by the above figures.

The timing of mating and lambing periods may prove to be affected by the frequency with which conditions suitable for the growth of pasture occur. Mating is governed in large measure by the period of the maximum onset of oestrus (1), but the selection of mating periods will be associated with a wider opportunity for choice as the mean period of influential rainfall and the expectancy of favourable seasons, which in South Australia are directly related to each other, both increase. From the data of Wark (4), the expectancy of favourable conditions of moisture for any period, and for any time of the year, can be determined.

Summary

Methods previously employed in South Australia for determining the climatic basis of the type of pastoral and agricultural production practised have been utilised further to assess wet-season variability in association with fat-lamb production.

Relationships have been established between the mean length of the period of influential rainfall and the maximum expected occurrence of effective rainfall periods of (a) 4 months and (b) 5 months, as determined by Wark (4), in each case dating from the first month for which the highest values obtain. From these relationships, corresponding values have been calculated for more than 200 stations, and maps constructed to compare the distribution of fat lambs, as shown by Thompson (1), with the rainfall expectancies found.

The climatic resources of the South-East, Mount Lofty Ranges and Kangaroo Island, which together account for practically the whole of the areas receiving an expected occurrence of 90% or more of seasons of sufficient duration to raise fat lambs satisfactorily, without hand-feeding, are emphasised.

The importance of taking advantage of the prevailing climatic conditions by improving soil fertility in these areas, and of making provision for the drought years that will inevitably occur in all other portions of the State, is demonstrated by the analysis undertaken.

Acknowledgments

Acknowledgment is made to Mr. E. A. Cornish, Section of Mathematical Statistics, C.S.I.R., for advice on statistical treatment, and to Miss Helen Ferres, who carried out the statistical determinations; the delineation of the maps was the work of Mr. E. J. Leaney.

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THE SODA-RICH LEUCOGRANITE CUPOLAS OF UMBERATANA

BY D. MAWSON AND W. B. DALLWITZ (READ 12 APRIL 1945)

Summary

Umberatana is located in the far northern portion of the Flinders Ranges, distant in an air line about 336 miles from Adelaide (see locality map, p.23). It forms the south-western margin of that belt of mountainous, igneous and metamorphic country which surrounds Mount Painter. The latter is rather widely known as the locality where radium-bearing minerals have been located amongst the depositions of the aftermath of granitic intrusion.

THE SODA-RICH LEUCOGRANITE CUPOLAS OF UMBERATANA

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[Read 12 April 1945]

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LOCATION AND GEOLOGICAL SIGNIFICANCE

Umberatana is located in the far northern portion of the Flinders Ranges, distant in an air line about 336 miles from Adelaide (see locality map, p. 23). It forms the south-western margin of that belt of mountainous, igneous and metamorphic country which surrounds Mount Painter. The latter is rather widely known as the locality where radium-bearing minerals have been located amongst the depositions of the aftermath of granitic intrusion.

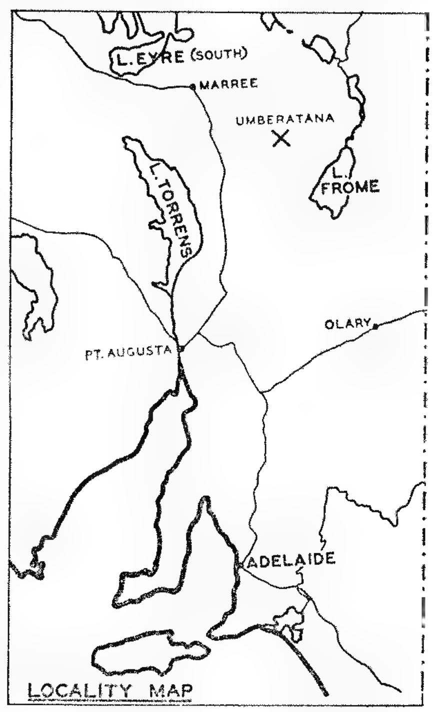
Within two miles of the homestead of Umberatana sheep station, in a region of only moderate physiographic relief, there are a number of small granitic outcrops, the largest of which is known as the Giant's Head (see area map, p. 24). Situated within a few miles to the east and east-south-east of Giant's Head are three other outcrops of a similar nature: the first of these, barely 3 miles distant, is distinguished as Tourmaline Hill locality; the third is The Needles, located a further 3 to 3½ miles on; the fourth is The Pinnacle and Sitting Bull locality situated some 6½ miles to the south-east of The Needles. The extreme limits of this zone of outcrops thus exceeds 13½ miles in length.

The many individual outcrops occurring in this belt are all small in cross-section. A close study of them yields convincing evidence that they represent the very summits of cupola-form masses which ascend from a large scale intrusive body evidently located at some depth below. It is not remarkable, therefore, that

the rocks of such a unique igneous emplacement have proved to be unusual, and thus interesting in their chemical and mineral characters.

The intruded sediments are of Proterozoic age, corresponding to what in the southern portions of the State have been designated the Adelaide Series. This stratigraphical horizon has been established as the result of extended traverses run across the neighbouring country. The location of a glacial horizon at Umberatana in normal relation to other established features of the Proterozoic sedimentary succession has fixed it as of Sturtian age. Underlying the glacial horizon are limestones and dolomites evidently equivalent to the Beaumont dolomites of the region near Adelaide; these have suffered thermal metamorphism as a result of the intrusion. It is to be noted that the intrusions are located in this calcareous belt.

The easterly extension of the line of outcrops lies within the territory known as Arkaroola sheep station. There these intrusions penetrate what appears to be a lower horizon of the calcareous belt, for the tillite in a steadily southward dipping series is further removed to the south. Also, in this area, gneissic and foliated rocks of the central Mount Painter belt are located to the north within about a mile of the line of intrusion.

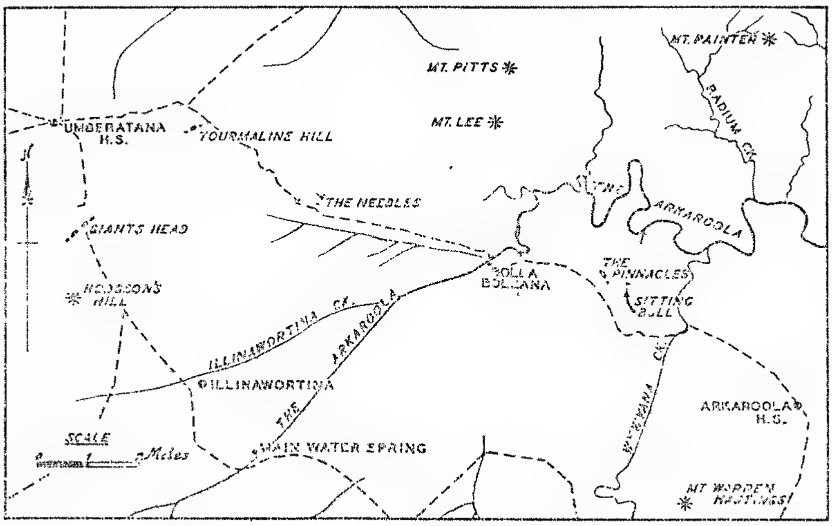


In the region to the south and south-east of The Pinnacle, the intruded sedimentary series has escaped any noteworthy degree of metamorphism and the succession of the beds is clearly and simply recorded. A traverse across portion of that area, from Mount Jacob to the neighbourhood of Mount Warren Hastings, was recorded by one (9) of us some years ago. The results of a later more detailed examination by us along the same line of section have not yet been published, but the existence of a major north-south fault line on the east side of the Cave Hill limestone was established. It was ascertained that the formations traversed in the section from Cave Hill towards Mount Warren Hastings represent a section of the Proterozoic succession stratigraphically lower than the beds to the east of the line of the Cave Hill limestone. To the west of the latter are beds of argillites, dolomites, and magnesite, evidently equivalent to the Beaumont dolomite section of the Adelaide Series, and to the dolomite and magnesite series situated to the west of Copley. It was from a creek boulder of a dolomite of this locality, collected by one of us, that the late Frederick Chapman (3) described a peculiar structure as being the accumulated remains of a calcareous alga, to which he gave the name *Mawsonella wooltanensis*. During our visit in 1940 we were able to further investigate this structure at its *in situ* location, and discovered it to be entirely of inorganic origin. The structure, where it resembles an accumulation of algal segments, is a compact mass of pellets of magnesite mud deposited in shallow waters, originally plastic and subsequently flattened by load stress.

In the neighbourhood of Mount Warren Hastings the dolomite series is overlain by the Sturtian glacial and fluvioglacial beds, a repetition of the succession at Mount Jacob. It is logical to assume that the outcrops which are the subject

of this investigation, on account of their contemporaneity and consanguinity, all proceed from the same parent granitic mass below. The introduction of the latter must have happened at the time when the Proterozoic and Lower-Cambrian rocks of the neighbourhood were being uplifted and thrown into great domes and basins. Elsewhere (12) we have shown that orogenic period to be probably of Late-Cambrian age.

The question arises as to whether the parent magma of our cupola outcrops is represented by any of the granitic contributions within the central complex of the Mount Painter belt. If represented at all, such would be expected to show little evidence of stress, for the region has apparently not been subjected to great dynamic forces since the period of the cupola intrusions. Only the red, kali-



alaskite (see analysis V in table on p. 32) of the Mount Painter region appears to conform to this requirement. But the fact that an erratic of red alaskite resembling that of the Mount Painter belt was found (10) in the Sturtian tillite of Mount Jacob, a locality somewhat further to the east, appears to negative the suggestion of possible contemporaneity of these two groups of granitic intrusions. In the absence of detailed mapping of the Mount Painter belt it is not possible to further discuss the possible relationship of the kalialaskite of that region with alaskites forming our line of outcrops extending from Giant's Head to Sitting Bull.

THE RESPECTIVE FIELD OCCURRENCES

The Giant's Head Locality

The occurrence of an unusual variety of igneous rock at this locality has long been known, attention having been drawn to it by W. B. Greenwood, one-time manager of Umberatana sheep station, on which run it is located. Reference to it was made long ago (9).

The location is 2 miles south of Umberatana Head Station on the track to Illinawortina. There a number of small outcrops, about 17 in all, as shown in the sketch plan (p. 26), extend along a length of somewhat over 1,100 yards following the direction of strike of the country. The largest of these, the Giant's Head itself, so named on account of its appearance when seen at a distance, is 160 yards in greatest length, and its summit is 100 feet above its lowest exposure.

In their general type, the rocks of these outcrops are highly sodic leucogranites. Albite is the outstanding feldspar, but is usually associated with more

or less microcline or microcline-perthite. Only in the case of exposure of the deeper portion of the intrusion is typical granitic texture and character presented. Most of the exposures, both texturally as well as mineralogically, have the characteristics of aplitic, pegmatitic or pneumatolitic formations.

The intruded rocks are Proterozoic slates, limestones and dolomites. From the latter, shoaded fragments of magnesite have been found on the surface of the ground to the east of No. 6 outcrop. Boulder-bearing fluvioglacial sediments were noted in the near vicinity. A roughly domed arrangement of sediments has been observed in the neighbourhood.

In this locality no special observations have been made concerning metamorphic contact phenomena, but an odd specimen [5924] (see p. 43) collected near the contact towards the western end of the intrusion has proved to be interesting scapolite-bytownite-phlogopite-hornfels.

NATURE OF THE INTRUSIVE ROCKS

Outcrop No. 1 is the most westerly granitic body in this area (see sketch plan, p. 26). The rock occurring here is irregular in character. In part it is a very fine-grained, white, sodic (albite) leucogranite,[1] carrying occasional pink garnets which were observed up to 0·5 cm. diameter. The more typical rock is albite-leucogranite [5844] (see p. 34).

A specimen [6119] from a more siliceous portion of the outcrop is constituted of quartz and albite and was probably formed during a pneumatolitic or hydatogenous period of consolidation, as illustrated by parallel vein structures and residual drusy fissures.

Outcrop No. 3 is the Giant's Head mass (pl. i, fig. 2). A chemical analysis of each of two varieties of the granitic rock from here is available. The first of these, from the summit of the outcrop, was analysed for one of us some time ago by W. S. Chapman (10). It is slightly-pinkish, medium to coarse-grained muscovite-albite-microcline-leucogranite [2875] (see p. 31). This represents a phase of the intrusive rock remote from its contact margin.

The other rock from the Giant's Head of which we have an analysis is illustrative of a tourmaline-bearing phase of a fine to medium-grained albite-microcline-tourmaline-leucogranite [2876] (see p. 31). This was analysed by Dr. A. R. Alderman (10).

From the middle of the north side of the mass we obtained a medium-grained flesh-coloured microcline-albite-leucogranite. Somewhat finer-grained and nearer white in colour is the albite-microcline-leucogranite [6108] of the east end of the mass. In some portions of the outcrop, rocks otherwise very similar to [6108] differ mainly by having small clots or irregular distributions of black tourmaline [6110 and 6008] or garnet in addition to the tourmaline [5914] (see p. 33).

Outcrop No. 5 is specially remarkable for including a large area, especially on its north side, of a peculiar, fetid albite-leucogranite [6001] (see p. 34). This extends under surface detritus for some distance beyond the obvious northern margin of the outcrop. Where most typically developed, this fetid rock is a spongy granular mass, less resistant to erosion than other portions of the intrusion. Dust caught on its rough surface discolours the white of the albite and has developed a general brown colour over the outcrop. In several places in this part of the mass isolated large crystals, one of them 6 inches long of brown, characteristically wedge-shaped sphene were observed. Where a coarse albite-quartz-sphene-pegmatite [6010] (see p. 37) contacts the fetid rock this sphene is strongly developed. Sphene is also very abundant in the pegmatite,

[1] The term leucogranite is here given the special connotation of Hatch and Wells (4), not that of Johannsen (6).

occurring in characteristic wedge-shaped crystals, and is exactly similar to that in the fetid rock.

Towards the east end of the outcrop fragments of both microcline-perthite and of albite are scattered on the surface. The latter collected here are very finely twinned and have irregular, often elongated fluid inclusions.

Outcrop No. 6 is the most easterly mass. It is mainly a white, medium-grained saccharoidal, microcline-albite-leucogranite [6110]. At the eastern end black tourmaline makes its appearance in small quantity. This tourmaline is in poikilitic clots and whisps, which at times have a dendritic appearance as observed on the outcropping face [5925] (see p. 33). Rarely, there are local patches richer in black tourmaline. Here also there is a notable development of coarsely crystalline albite, much of it as runite, graphic intergrowths with quartz (pl. ii,

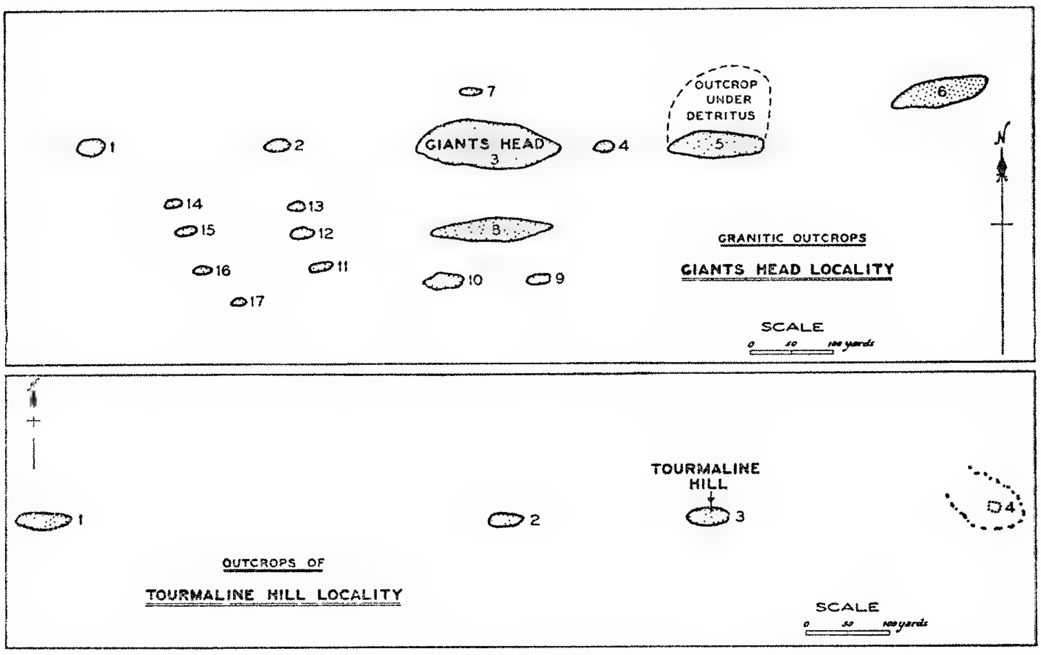


fig. 3); in these the quartz lamellae are approximately at right angles to the two cleavages of the feldspar.

Outcrop No. 8 is in part a medium but variable grain-sized, microcline-albite-muscovite-leucogranite [6006] (see p. 35); this rock forms the summit of the mass. Rock from three-quarters of the way up the north-west side is a coarse-grained microcline-albite-(biotite)-leucogranite [6002] (see p. 35).

Outcrop No. 12 is represented by a white albite-leucogranite [6128] in which the plagioclase is notably euhedral. Microcline in very small quantity is present in antiperthite. Accessory black tourmaline in small grains is distributed through the rock.

Outcrop No. 13 is an off-white, albite-microcline-(muscovite)-leucogranite.

Outcrop No. 15. Medium to fine-grained albite-microcline-leucogranite with coarser pegmatitic schliers, some of which carry a little muscovite, others a little black tourmaline. In some, specks of sphene and apatite are visible.

Outcrop No. 16. An off-white, medium to fine-grained, albite-microcline-quartz-leucogranite with traces of biotite.

Outcrop No. 17. Albite-microcline-leucogranite with a little biotite and odd grains of tourmaline.

Tourmaline Hill Locality

Tourmaline Hill is situated about 3 miles south of Umberatana Head Station. The actual outcrop that carries that name does so by virtue of the fact that abundant crystals and fragments of black tourmaline weathered out from the intruding mass litter the surface for a considerable area in that vicinity. From among this shoaded material many well-formed crystals have been collected, and the crystal morphology of some has been recorded (13). In all there are three outcrops to be considered in this locality respectively numbered, from west to east (as Nos. 1 to 3) on the sketch plan (p. 26); of these Tourmaline Hill itself is No. 3. The location No. 4 appearing on the plan is where it is thought that igneous rock lies not far below the surface; though nothing more is met with among the calc-silicate marbles of the outcrop than stringers and patches of quartz. Outcrops Nos. 1 to 3 are all small in area and each obviously represents the summit of an intrusive mass, only the upper tip of which has reached above the level of the present ground surface. It will be observed that they are all in linear arrangement corresponding with the strike of the intruded rocks. The latter, as at the Giant's Head, are limestones, dolomites and argillaceous rocks flanked nearby to the south by fluvioglacial sediments, which latter indicate a late Proterozoic age for the formation.

The metamorphic effect of the intrusion has been not merely to decarbonate, dehydrate and recrystallize the intruded sediments, but the latter have received large additions of substances bodily transported from the igneous source by a process of transfusion.

Metamorphism in a mild form has affected the sediments at distances of hundreds of yards across the strike from the axis of intrusion developing obvious spots and flecks in the argillaceous rocks. However, it is only within a distance of about 250 yards that general recrystallization is evident in the hand-specimen; it is within the last 150 yards that the more remarkable, coarse-grained, and radical recrystallizations are located.

The absolute contact is not infrequently a dark, irregular, highly micaceous type of rock exemplified by [6015] and [5152] (see pp. 39 and 40), which may be regarded as a quartz-albite-zinnwaldite-hornfels.

Many of the outcrops adjacent to or at no great distance from the igneous intrusions are scapolite-bearing, for example [5923] (see p. 42) which is a scapolite-tremolite-biotite-hornfels [6022] (see p. 41) a scapolite-biotite-(vesuvianite)-hornfels, and [6021] (see p. 42) a scapolite-biotite-hornfels. In some of these scapolite-biotite-hornfels [6106] (see p. 43) the scapolite blasts conform to a faint relict structure outlining original sedimentary laminae. At about 200 yards distant from the igneous outcrop at Tourmaline Hill, what appears to have been originally a similar sediment to that which developed into the above scapolite-bearing hornfels is merely a low-grade biotite-feldspar-quartz-hornfels [6024] of very fine grain-size. One rock specimen [6026] (see p. 41) collected very close to the igneous albite-rich pegmatitic rock of Tourmaline Hill has a structure quite similar to [5923] but the ovoid blasts are merely albite; scapolite is absent.

A notable part of the original sediments of this locality were dolomitic limestone; these have been transformed to tremolite-albite-biotite (phlogopitic)-marble [6105, 5922 and 6011] (see pp. 41 and 47), an albite-biotite-marble [6025] (see p. 46), an albite-bearing dolomitic marble [6027] (see p. 45), and albite-glaucophane-siderite-marbles [6028 and 6029] (see pp. 44 and 45).

The Intrusive Rocks

No. 1 outcrop is about 60 yards long and 40 feet high above the creek nearby. The rocks are schlieric and pegmatitic albite-bearing varieties, *e.g.*, [6116].

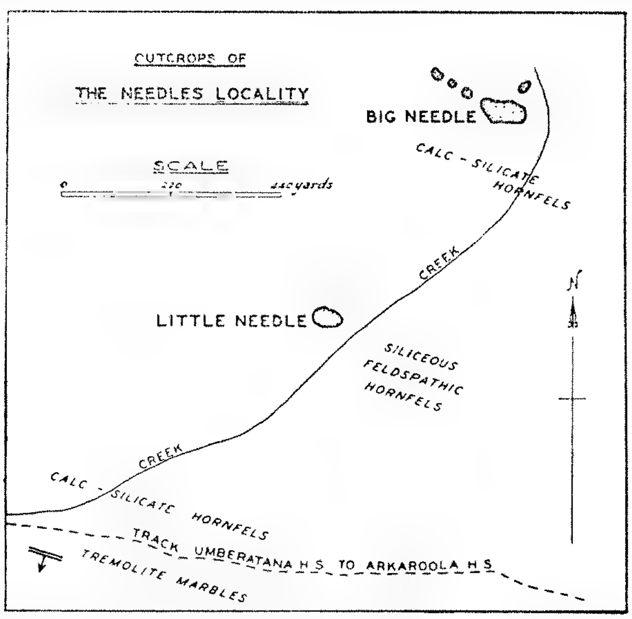
A very little white mica, grains of green apatite and some black tourmaline are sometimes present. One interesting type represented is a microcline-albite-tourmaline-leucogranite [6000] (see p. 36). A large block of feldspar measuring 12 inches by 12 inches by 9 inches from this outcrop was found to be microcline-perthite in which the albite takes the form of long and wavy streaks, some of which show multiple twinning in the hand-specimen (pl. ii, fig. 4).

No. 2 outcrop is also about 40 yards long and composed almost exclusively of quartz and feldspar.

No. 3 outcrop, which is Tourmaline Hill itself, is not more than 45 yards in greatest length. A typical rock of this outcrop is represented by [6019], which is a very fine-grained, white saccharoidal aggregate of subhedral albite crystals with a length of about 1 mm, amongst which are embedded irregular grains of quartz. Potash feldspar is absent in the rock slide. Tiny grains of black tourmaline are widely dispersed through this rock. Elsewhere the outcrop is coarsely pegmatitic, the most striking form of which is exemplified by [6007] (see p. 38). This is coarsely crystalline, composed of white albite, black tourmaline, green apatite, red garnet and glassy quartz. The feldspar in these coarse-grained portions of the outcrop is usually a very pure form of albite in bladed masses, often radially arranged.

The Needles Locality

Some 3 miles east-south-east of Tourmaline Hill are granitic intrusions known as The Needles. There, soda-rich leucogranite, with associated veins and patches of pegmatite, outcrops in two major masses of pyramidal form with some aligned subsidiary extensions (see plan below). The pyramidal igneous masses which are known as "The Needles" have a quite striking appearance (pl. i, fig. 1). Like those of the Giant's Head locality, they are located in a belt of Proterozoic



dolomites and limestones. The intruded rocks show the effect of mashing and transgression at contacts. The carbonate rocks and the argillaceous and arenaceous beds associated therewith all exhibit the effects of thermal metamorphism; in adjacent areas, say within 200 yards of the intrusive rocks, there is clear evidence of wholesale introduction into the intruded formations of certain constituents from the intruding magma. The more obvious of the transported elements are soda and chlorine, resulting in the development of hornfels rich in albite and scapolite.

The track from Umberatana to Arkaroola passes within several hundred yards of the Little Needle (see plan, p. 28). In that neighbourhood the track traverses spotted slates and marbles rich in tremolite and actinolite. It follows along the strike, which trends about E. 15° S.; the dip is moderately steep in a southerly direction.

In the vicinity of the Little Needle highly siliceous, feldspathic types of hornfels occur. Hornfels of this kind forming a high hill situated to the south-east of the igneous outcrop appears to have been siliceous sediments into which a large amount of feldspar, principally microcline, has been introduced, developing microcline-quartz-muscovite rocks.

Magnesia-rich calc-silicate hornsfels again appear in the neighbourhood of the "Big Needle." In this locality a tremolite-scapolite-hornfels [6014] (see p. 44) was collected.

INTRUSIVE ROCKS

The Little Needle, which is about 50 feet in height, is almost entirely composed of a uniform white, fine-grained, richly-albitic-leucogranite [6121].

The Big Needle is located about 600 yards further to the north-east. Its height from base to summit is about 150 feet. Here again the granitic rock is a microcline-albite-leucogranite, but is relieved by irregular pegmatitic veins and patches, in some of which microcline and microcline-perthite are well developed. Occasional patches of fine-granular black tourmaline, often poikilitically arranged, are distributed through the rock; coarser black tourmaline appears in small quantity in narrow, coarse-grained pegmatitic concentrations.

At the summit of the intrusion, tiny pink garnets are distributed through the rock [6023] (see p. 36). Here also are occasional patches of green apatite, and some black tourmaline.

There is a considerable development of coarse, pegmatitic, quartz-feldspar rock in the north-westerly extension of the Big Needle. There, large feldspar crystals in masses up to 20 lbs. in weight are microcline and microcline-perthite.

In the upper portion of the Big Needle a patch of brown sphene was located and in its north-western extension there are patches of dravite, a brown magnesia-rich tourmaline [6017] (see p. 39).

Mica in any form is a rarity in the body of these intrusive masses, though some coarse plates of both white and black phlogopitic mica occur here in a pegmatitic patch at the north-west end of the Big Needle; however, at the contact of the intrusive and intruded rocks the latter has been metasomatically reconstituted and may be highly micaceous, as exemplified by a phlogopite hornfels [6016] collected at the north-western extension of the Big Needle outcrop.

The Pinnacle and the Sitting Bull Locality

The Pinnacle is a striking granite mass of pyramidal form (pl. ii, fig. 1) located about a half-mile north of the track from Umberatana to Arkaroola at a point 2½ miles east of Bolla Bollna. It is about 7 miles east-south-east of the Needles (see map, p. 30). The rocks intruded are the eastward extension of the same belt as encountered at the Needles. Once again dolomitic limestone and associated shales have been converted by the intrusion to tremolite and marble and other calc-silicate rocks and hornfels. One variety collected is an albite-tremolite-muscovite rock.

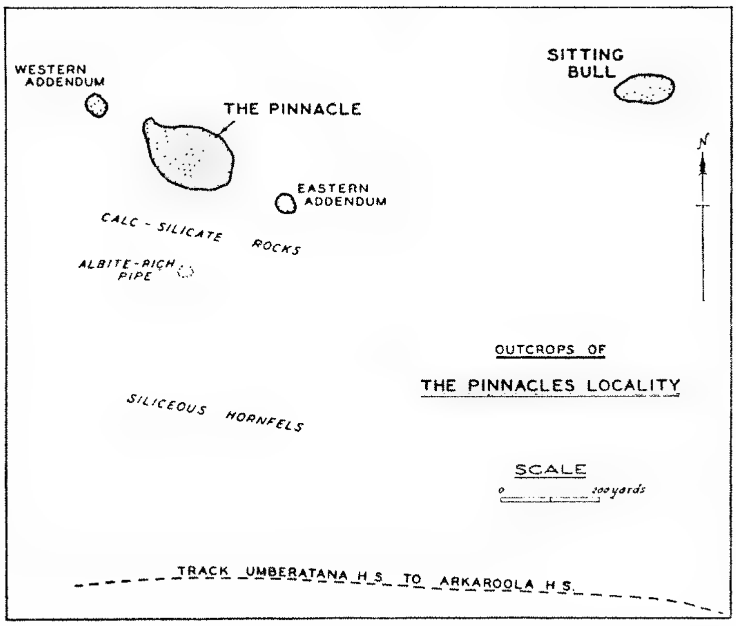
A notable development in a belt within 200 yards of the main intrusion is an albite-magnetite-quartz-hornfels [5154]. Weathering out of the latter and

mantling the surfaces thereabout are octahedral magnetites as much as 4 cms. in cross-section; some have stepped faces, the result of oscillatory growth. In several places at the immediate contact with the intrusive mass, the sediments have been converted to highly micaceous hornfels such as the albite-tourmaline-biotite-quartz-hornfels [5841] (see p. 40) collected at the igneous contact of the Eastern-Addendum (see plan below), and a variant [6163] from the contact of the main intrusion which contains honey-yellow crystals of sphene 2 mm. diam. distributed through the dark micaceous matrix.

In this same locality but half-a-mile east of the Pinnacle is another considerable granite outcrop, which on account of its peculiar outline, is known as Sitting Bull.

INTRUSIVE ROCKS

The Pinnacle is a pyramidal mass with some minor extensions. It is elongated in a direction roughly north of west to south of east, and at the base its diameter is about 150 yards. Its height from the lowest exposure to summit is in the



neighbourhood of 200 feet. The mass of the rock is a microcline-albite-leucogranite [6009], which is very similar to that of Sitting Bull but contains a little less quartz and somewhat more abundant albite, the ratio of albite to microcline being about 1 to 1. Occasionally a little black tourmaline makes its appearance, usually in small symmetrical patches.

This rock which is typical of the intrusion is replaced at intervals over the outcrop by local variations in texture and even in mineral character. One such [6018] is a granitoid albite-mica-orthoclase-quartz rock which appears to be hybrid. In it the black mica has a value 2V about 16°. Both the feldspars are fresh in appearance but there is evidence that the orthoclase has been in process of replacement by albite.

Coarse pink feldspar of a pegmatitic schlier in this granite mass was proved to be albite, but a paler pink feldspar associated with it is microcline-perthite.

The low, subsidiary outcrop, designated the Western Addendum is a white albite-leucogranite carrying very small quantities of tourmaline and biotite

[6004] (see p. 36). Here also was collected from an irregular pegmatitic patch a very large crystal of feldspar which has proved to be pure albite.

A further auxiliary mass, the Eastern Addendum, located on the axial line to the east of the Pinnacle is a pyramidal body of peculiar nature. Here the rock is unusual in appearance and in its freedom from any coloured constituent or mica. It is a snow white, saccharoidal albite-microcline-leucogranite [5153] (see p. 34). A block of feldspar from a pegmatitic formation in the marginal zone of this mass was found to be pure albite.

At Sitting Bull the main rock in a flesh-coloured microcline-albite-leucogranite [6005] (see p. 37). Crystals and granular patches of tourmaline occur in portions of this intrusion.

PETROLOGICAL DESCRIPTIONS

Intrusive Rocks

LEUCOGRANITES

MUSCOVITE-ALBITE-MICROCLINE-LEUCOGRANITE [2875]: Giant's Head

A medium to coarse-grained, granitoid rock which tends to be porphyritic. In the hand-specimen it is seen to consist of white plagioclase, quartz and larger flesh-coloured potash-feldspar and muscovite. One exceptionally large but irregular crystal of potash-feldspar is 3 cms. long, but the average length of the larger feldspars is 1 cm. Some grains of the potash-feldspar have a narrow shell of plagioclase.

Microscopic Observations—The size of the bulk of the mineral grains in the slide is about 5 mm. Anhedral, slightly perthitic microcline, subhedral albite (less An than 5%) and anhedral quartz are the principal minerals. Although the larger grains often contact each other in the manner typical of granitic texture, they are frequently partly bordered by a fine-grained aggregate of albite and quartz; there are also some medium-sized interstitial grains of the same minerals, together with a little microcline. The fine-grained aggregate sometimes intersects the potash feldspars. Fluid inclusions are specially abundant in the potassic feldspar. The other essential mineral is muscovite. Extremely rare specks of blue tourmaline and black iron ore complete the list of minerals.

A chemical analysis of this rock executed by W. S. Chapman is given in the table on page 32. From this the norm has been calculated as follows:

Quartz	25·49	Magnesite	0·08
Orthoclase	23·35	Ilmenite	0·10
Albite	44·60	Apatite	0·34
Anorthite	1·68	Water	1·31
Corundum	2·75		
En	0·50	Total	100·46
Hy	0·26		

C.I.P.W. classification: Class I, order 4, rang 1, sub-rang 1.

ALBITE-MICROCLINE-TOURMALINE-LEUCOGRANITE [2876]: Giant's Head

This is a fine-grained, somewhat saccharoidal rock consisting of faintly-pinkish white feldspar, semi-vitreous quartz, and black tourmaline. In some areas the rock is quite free from tourmaline, in others there are isolated grains of that mineral, while often there are patches several inches across thickly studded with it.

Microscopic Observations—Almost pure albite (symmetrical extinction about 17°) is easily the most abundant mineral; the other essential constituents are quartz, microcline and tourmaline. Hiatal texture is conspicuous. Between

grains of the four principal minerals averaging 1 mm. in size lie fine-grained aggregates of albite and subordinate quartz. In general the albite is subhedral, but the quartz and microcline have very irregular boundaries. The tourmaline, which is pleochroic from very dark, almost opaque bluish-grey to light greyish-purple, is also anhedral and nearly always poikilitically includes feldspar and quartz. Whisps of muscovite appear only very rarely.

A chemical analysis of this rock executed by A. R. Alderman is given in the table on page 32. The boron content indicates it to have a tourmaline content of about 2%. Assuming for this the mean composition of black iron-magnesium tourmaline, the norm has been calculated as:

Quartz	32·32	Tourmaline ...	2·00
Orthoclase	18·35	Apatite	0·35
Albite	43·75	Haematite	0·32
Anorthite	1·11	Water	0·33
Corundum	1·63		
		Total	100·06

C.I.P.W. classification: Class I, order 4, rang 1, sub-rang 4.

TABLE OF ANALYSES

	I	II	III	IV	V
SiO_2	72·34	75·36	76·90	76·02	72·06
Al_2O_3	16·30	14·64	13·75	14·60	15·10
Fe_2O_3	0·06	0·35	0·34	0·27	0·47
FeO	0·22	0·17	—	0·08	0·17
MgO	0·20	0·12	0·22	0·04	0·12
CaO	0·50	0·49	0·20	0·34	0·62
Na_2O	5·26	5·48	6·26	7·08	0·15
K_2O	3·97	3·25	2·78	0·96	11·14
H_2O+	1·25	0·12	0·15	0·34	0·59
H_2O-	0·07	0·21	0·05	0·15	0·01
CO_2	nil	nil	nil	—	nil
TiO_2	0·05	trace	0·03	0·07	0·14
P_2O_5	0·13	0·19	—	—	0·02
B_2O_3	—	0·19	—	—	—
MnO	0·01	—	—	—	nil
BaO	nil	—	—	—	nil
ZrO_2	—	—	—	—	nil
Cl	nil	—	nil	—	nil
F	—	—	—	—	nil
SO_3	nil	—	—	—	nil
Fe as (Fe_2)	nil	—	—	—	0·07
Rare Earths	—	—	—	—	nil
	100·36	100·57	100·68	99·95	100·66

I. Muscovite-Albite-Microcline-Leucogranite [2875]. Analyst: W. S. Chapman, Analytical Laboratory, Mines Department, Adelaide.

II. Albite-Microcline-Tourmaline-Leucogranite [2876]. Analyst: A. R. Alderman, University, Adelaide.

III. Albite-Microcline-Leucogranite [5153], The Pinnacles Umberatana, South Australia. Analyst: W. T. Dalwood, Analytical Laboratory, Mines Department, Adelaide.

IV. White soda aplite, Port Elliot, South Australia. Analysed and recorded (2) by W. R. Browne.

V. Pink Potash Leucogranite (the Kalialaskite of Johannsen) [2881] from one mile north of Mount Painter. Analysed by W. S. Chapman and recorded (10) by Mawson.

ALBITE-TOURMALINE-MICROCLINE-LEUCOGRANITE [5925]: Giant's Head Locality

A medium-grained, saccharoidal rock composed essentially of faintly greyish-white feldspar, semi-vitreous quartz and black tourmaline concentrated in local patches. The tourmaline-rich part passes suddenly into rock almost devoid of that mineral. Pore-spaces are sometimes present between feldspar crystals. Close scrutiny reveals occasional tiny pockets of a pale, faintly yellow-green mica.

Microscopic Observations—The texture is dominated by the presence of euhedral, roughly equidimensional crystals of pure albite whose average grainsize is 2 mm. Occupying the spaces between the albite crystals are tourmaline, quartz, and microcline.

The tourmaline is poikilitically disposed over considerable areas. Its pleochroism seems to be from very dark, almost opaque brown to light nigger-brown, sometimes with a purplish tinge. This mineral anastomoses in the most complicated way between the albite crystals and is never idiomorphic. Often it contains small inclusions of microcline, and in a few cases it, sometimes together with quartz, veins that mineral. From this evidence it is clear that boron-containing vapours, at a late stage, invaded the rock and attacked the microcline to deposit tourmaline, while the albite was untouched.

At least some of the albite seems to have had a special mode of origin, for many grains contain irregular pieces of microcline of various sizes. These are of the nature of residual cores veined by albite. Thus it appears that, before the tourmalinization, some microcline was replaced by albite. In a number of cases tourmaline occurs within albite crystals; probably it has replaced microcline residua there, for it closely simulates their shapes.

Many crystals of albite contain flakes of muscovite of various sizes; these usually lie in the central parts of the feldspar and in a few cases they attain a fair size and occupy a large part of the grains; (001) of the muscovite is often parallel to (010) of the host. Probably the mica resulted from a late-magmatic activity connected with the albitization and tourmalinization of the microcline.

The feldspars appear to be completely fresh, but they contain very many irregularly distributed fluid and dusty inclusions; in albite crystals carrying residual microcline, these inclusions are more abundant in the potash-feldspar. The quartz is remarkable in that it is almost free from inclusions of any kind. One small grain of apatite was seen in the slide.

MICROCLINE-ALBITE-TOURMALINE-(GARNET)-LEUCOGRANITE [5914]: Giant's Head Locality

A fine-grained, faintly pinkish-white, aplitic rock consisting of feldspar, semi-vitreous quartz, patches of black tourmaline and scattered red garnets.

Microscopic Observations—Anhedral, microcline, quartz and subhedral albite are the essential minerals. The grains are in two groups, the first composed of much larger individuals than the second, which consists mainly of small individuals of albite and quartz. Sometimes the microcline is slightly perthitic; in the plagioclase $X' \wedge (001) \perp Z = 22°$, which corresponds to pure albite. Both feldspars contain abundant fluid and granular inclusions. In the closely related rock [6008], the plagioclase contains about 6% of the anorthite molecule.

Dusty and gas-liquid inclusions are abundant in the quartz, the latter being rather unevenly distributed and often unusually large.

Tourmaline, garnet and a little muscovite are the accessories. The tourmaline is a dark variety pleochroic from very dark grey-black to chocolate brown. It is in very ragged grains which enclose quartz and feldspar, and has probably been formed from microcline by metasomatic replacement. The garnet which is

present in individuals up to 0·5 cm. diameter, is pale pink in transmitted light and poikilitically includes much quartz; it, too, is in very irregular grains.

ALBITE-MICROCLINE-LEUCOGRANITE [5153]: Eastern Addendum at The Pinnacles

In a fine-grained saccharoidal base of white feldspar are set scattered grains of vitreous quartz usually 1 to 2 mm. in diameter with occasional extreme cases, as much as 4 mm. diameter (pl. ii, fig. 2).

Microscopic Observations—In a matrix of subhedral albite and anhedral microcline of average grain-size about 0·5 mm. or less are embedded anhedral grains of quartz (pl. iii, fig. 1). A few gas-liquid inclusions are present in the latter, while the feldspars, which are perfectly fresh, contain granular and some irregular fluid inclusions.

Minute traces of apatite and black iron-ore are the only accessories; a little leucoxene was observed bordering one grain of the latter.

This rock is closely related to [6005], differing mainly in that the feldspar is of finer grain.

A chemical analysis executed by W. T. Dalwood is given in the table on page 32. This yields the following norm:

Quartz	29·01	En	0·55
Orthoclase	16·68	Haematite	0·29
Albite	52·92	Ilmenite	0·06
Anorthite	0·97	Water	0·20
Corundum	0·05		
		Total ...	100·73

C.I.P.W. classification: Class I, order 4, rang 1, sub-rang 4.

In Johannsen's classification this would be a leuco-sodaclase-granodiorite.

ALBITE-LEUCOGRANITE [5844]: Giant's Head Locality

Somewhat saccharoidal, medium-grained, slightly porous rock of even texture. Purplish flesh-coloured feldspar, usually as euhedral equidimensional grains, and semi-vitreous quartz are the obvious minerals.

Microscopic Observations—Euhedral to subhedral plagioclase and anhedral quartz are the only two minerals present apart from rare accessories. The feldspar is apparently quite fresh but is speckled with fluid and dusty inclusions; it usually has a narrow zonal shell and determinations on the two parts gave $X' \wedge (001) \perp Z = 15° = An_{10}$ for the core and $X' \wedge (001) \perp Z = 22° = An_0$ for the extreme outside. The determination on the central part checked with the reading of 12° for symmetrical extinction. Only very rarely is the albite antiperthitic, the included mineral being microcline.

The accessories are a very little mica and rare grains of tourmaline. The mica is pleochroic from brownish white to almost colourless.

POROUS, FETID, ALBITE-LEUCOGRANITE [6001]: Giant's Head Locality

A medium-grained, spongy (abundant pore-spaces) and friable, saccharoidal rock consisting of white to colourless, usually transparent, pearly feldspar, vitreous quartz and tourmaline (extremely rare). When struck with a hammer a fetid odour is emitted.

Microscopic Observations—The texture of this rock is determined by the abundance of loosely-packed euhedral to subhedral crystals of fresh albite (maximum extinction angle in symmetrical zone = 17°). In grain-size the crystals average about 1·5 mm.; some of them are bent and partly broken. The twin-lamellae are very fine, and the pericline type is unusually common. Myrmekite and microcline-antiperthite are present in very small amount (pl. iii, fig. 2).

The feldspars contain some granular inclusions, and there is an abundance of irregular fluid inclusions. The gas from these released on fracture is the source of the fetid odour above mentioned. This is partly hydrogen sulphide, but the peculiar odour suggests the presence also of carbon-bisulphide. When a microscope section[2] of the rock is prepared without delay, the compressed liquid in the minute vesicles can be seen in a state of great agitation as the gas escaping through cleavage cracks, slowly volatilises. Within the period of a few hours the imprisoned gases, where they can get away, have all escaped.

An occurrence of fetid feldspar, referred to as necronite, was recorded long ago by Hayden (5).

Quartz is the only other mineral of any importance; it makes up about 35% of the whole. It is interstitial between the albite grains and carries a moderate number of gas-liquid inclusions.

Accessory minerals are present in minute amount only; they comprise leucoxene, fluorite, tourmaline, black iron ore and apatite. The fluorite is moulded on the albite, and not infrequently forms a thin lining to cavities.

MICROCLINE-ALBITE-MUSCOVITE-GRANITE [6006]: Giant's Head Locality

A rock of medium but variable grain-size, ranging from about 1 mm. in some parts to 3 mm., and up to 5 mm. in more richly micaceous irregular schliers. It consists of off-white feldspar, semi-vitreous quartz, notably abundant muscovite plumose in the coarse parts, and occasional grains of black tourmaline.

Microscopic Observations—Essentially composed of anhedral microcline-perthite, quartz, very subordinate subhedral albite (Ab_{96+}), and muscovite. The alkali-feldspar sometimes contains irregular blebs of quartz. Muscovite is plentiful in portions of the rock. No tourmaline appears in the rock section.

MICROCLINE-ALBITE-(BIOTITE)-LEUCOGRANITE [6002]: Giant's Head Locality

Coarse-grained, semi-pegmatitic rock consisting of flesh-coloured and off-white feldspars, semi-vitreous quartz, and biotite. The grain-size is variable; many grains are over 1 cm. across and most approach that size. The mica comprises probably not more than 1% of the whole, and it is unusual in that it occurs in extremely thin plates, which are often over 1·5 cm. across. A little black tourmaline is also visible.

Microscopic Observations—The texture is granitic. Microcline-perthite is predominant, occurring in irregular grains among which lie subhedral grains of plagioclase. Some granular plagioclase is found in the microcline-perthite. The feldspars are generally quite fresh and they contain irregular fluid inclusions. The slide available permitted only limited optical measurements of the plagioclase; a content of An_7 was indicated, but it is thought likely that the anorthite content is actually less than this. The quartz is interstitial and contains strings of gas-liquid inclusions. Pleochroism in the mica, which contains some haloes, is from nigger-brown to pale yellow. Accessories are present in minute quantity only; they are very dark brown sphene, black iron ore, brown tourmaline, muscovite and zircon.

MICROCLINE-ALBITE-LEUCOGRANITE [6003]: Giant's Head

A medium-grained, granitoid rock consisting of flesh-coloured and pinkish-white feldspars, vitreous quartz and very rare specks of tourmaline and flecks of muscovite. Blebs of quartz are present up to 5 mm. diameter.

Microscopic Observations—A rock of granitic texture, but of very uneven grain-size, which, however, averages about 2 mm. Anhedral microcline and

(2) Some details of this feature observed in a specimen from another portion of the outcrop are recorded in Mawson (8).

slightly perthitic microcline are the dominant minerals. Next comes subhedral albite (symmetrical extinction = 16°), which is often in crystals smaller than the average. The potash-feldspar sometimes contains granular quartz and plagioclase. All of the feldspars are quite fresh, but they carry many irregular fluid and a few granular inclusions. The quartz is interstitial. It contains a few gas-liquid and granular inclusions.

Accessories, which are very rare indeed, are muscovite, tourmaline (pleochroic from light steel-grey to light purplish grey) and black iron ore.

MICROCLINE-ALBITE-TOURMALINE-LEUCOGRANITE [6000]: Tourmaline Hill

Medium-grained, light-coloured, saccharoidal, granitic rock consisting of white feldspars, semi-vitreous quartz, unevenly distributed elongated black tourmaline, a very little pale blue-green apatite and very rare muscovite.

Microscopic Observations—The essential minerals, in order of abundance, are microcline, albite and quartz. The plagioclase is almost pure albite in lath-shaped, subhedral crystals which have a broad interstitial texture. Microcline, in shapeless interstitial grains, is dominant. Both feldspars are absolutely fresh; the albite and, to a lesser extent, the microcline, carries fluid inclusions. The quartz, also, is interstitial; it usually occurs in largish grains poikilitically enclosing quantities of both feldspars.

The tourmaline is in anhedral grains poikilitically disposed towards feldspars and quartz. It is zoned irregularly, with resultant mottled effect. Parts of some grains are deep cobalt blue, but longitudinal sections are pleochroic from very dark brownish-grey to pale violet-grey. Apatite, a few rods of black iron-ore and rare muscovite are the only accessories.

MICROCLINE-ALBITE-MUSCOVITE-GARNET-LEUCOGRANITE [6023]: The Big Needle

Medium-grained, saccharoidal rock consisting of white feldspar, semi-vitreous quartz, a little pearly, white muscovite and irregularly distributed icositetrahedra of light red garnet averaging about 2 mm. in diameter.

Microscopic Observations—An allotriomorphic-granular rock of uneven grain-size consisting essentially of microcline (very rarely slightly perthitic) quartz, albite, muscovite and garnet, in that order.

The grains of quartz and microcline are quite irregular, but the albite tends to be subhedral, and is apparently almost quite free from the anorthite molecule. The feldspars contain many irregular fluid and dusty inclusions but are only very slightly clouded by alteration. Gas-liquid inclusions are prominent in the quartz. Muscovite is in subhedral books.

The garnet is very pale brown in section and generally encloses a few grains of quartz and, less frequently, of albite and muscovite. Apatite and black iron-ore occur only extremely rarely.

TOURMALINE-BEARING ALBITE-LEUCOGRANITE [6004]: The Pinnacle

Medium-grained, slightly porous and somewhat saccharoidal rock consisting of white, somewhat pearly plagioclase, semi-vitreous quartz and a little black tourmaline. The quartz is blebby, frequently concentrated into irregular pockets up to 0·75 cm. across. Poikilitic patches of black tourmaline are visible.

Microscopic Observations—The texture is hypidiomorphic granular. Essential minerals are subhedral plagioclase and interstitial quartz. The average grain-size of the plagioclase is 1·5 mm., whereas that of the quartz is usually much coarser (hiatal texture). Some areas of plagioclase measuring several millimetres across are quite free from quartz. The plagioclase, which is about 100% albite, contains many fluid inclusions of irregular shape and is quite fresh.

Strings of gas-liquid inclusions are more common in the larger grains of quartz than in the smaller ones. These large grains also contain some plagioclase, and are often in optical continuity with smaller ones lying between the surround ing plagioclase crystals.

Tourmaline, pale biotite, a few spherules of leucoxene, and apatite are the accessories. The first, which is fairly abundant, is usually in dispersed grains which are in optical continuity over an area of about 0·5 sq. cm.; it is pleochroic from almost opaque blue-black to medium brown. The biotite, which is in less amount, sometimes fills the interstices between albite crystals.

MICROCLINE-ALBITE-LEUCOGRANITE [6005]: Sitting Bull

A granular, medium-grained rock consisting almost entirely of evenly distributed flesh-coloured feldspar and vitreous quartz, roughly in the proportion of 3:2. The quartz is considerably coarser than the feldspar.

Microscopic Observations — Irregular grains of quartz averaging about 2·5 mm. to 3 mm. are embedded in a "matrix" of feldspar of average grain-size about 0·8 mm. Two feldspars are present in nearly equal amount; subhedral albite (Ab_{96+}) and anhedral microcline. The microcline is somewhat in excess, and is a little coarser than the other. Some grains of albite are embedded in the quartz. Mica is a rare accessory; in some cases the core is muscovite surrounded by a narrow shell of biotite.

PEGMATITE SCHLIERS

ALBITE-MICROCLINE-QUARTZ-SPHENE-PEGMATITE [6010]: Giant's Head

A coarse, pegmatite constituted of very pale flesh-coloured albite in individuals up to 6 cm. across, which embed and surround irregular crystals and patches up to 3 cms. across of quartz, at times faintly smokey, and lozenges of sphene. Microscopic investigation shows the presence also of some microcline, but this is not obvious in the hand-specimen. This pegmatite occurs as an irregular pocket in the cellular, fetid, albite-leucogranite [6001].

Microscopic Observations—The leucocratic minerals consist of albite, which is apparently free from anorthite, quartz with a few gas-liquid inclusions, myrmekite, and small quantities of microcline. Some of the myrmekite is of a peculiar, spongy form which does not extinguish normally under crossed nicols; instead, a shadow-band moves along the intergrowth as the stage is rotated. The albite is either twinned in a very fine scale, untwinned or normally twinned. The microcline occurs as inclusions or partly bordering albite, and its presence in the microscope slide indicates that some of the coarser feldspar in the pegmatite itself is probably microcline. Both feldspars are quite fresh.

A few flakes and fine-grained aggregates of mica are present; it is pleochroic from golden-brown to light golden-yellow, and 2E appears to be about 25°. It appears to be zinnwaldite.

The sphene is in wedge-shaped crystals up to about 7 cms. by 1 cm.; these are dark brown and often quite vitreous internally but may be black, earthy and cellular in a superficial zone. Occasionally the latter characters permeate the entire crystal. A study of microscopic preparations has indicated that the original sphene was homogeneous and vitreous, but that subsequent reaction with residual liquors has had the effect of breaking down some of the sphene to non-homogeneous aggregates of ilmenite, leucoxene and sheets about 1 mm. thick containing quartz and feldspars ramify through the original crystal in an irregular manner.

Pleochroism in the sphene is variable but ranges between light maroon and silvery buff. The cleavage-lines are wavy and closely spaced. The dark colour of the outer parts (and often the whole) of certain of the crystals is due to the presence of small ilmenite grains; except at the margins where, however, they are often bordered by leucoxene.

The sphene has been subjected to a partial analysis by B. R. Lewis and the presence of 0·3% rare earth oxides established.

One near-basal section of light-blue tourmaline was observed.

ALBITE-TOURMALINE-APATITE-GARNET-QUARTZ-PEGMATITE [6007]: Tourmaline Hill

This is an irregular and coarse-grained rock composed of faintly-greenish-white albite in which are embedded large masses of black tourmaline, green apatite, clear reddish-brown garnet, and some clear semi-vitreous quartz.

Microscopic Observations—Detailed investigation reveals that the bulk of the rock is a felted and bladed mass, often in semi-radiating aggregates of elongated but usually anhedral albite crystals exhibiting irregular and interrupted twinning and markedly undulose extinction. In the hand-specimen the cleavage faces of the albite are seen to be wavy and bent. In addition to the minerals visible in the hand-specimen there is a little microcline, occasional flecks of muscovite, and rare scattered grains of black iron-ore, sometimes in needle-like crystals. Optical tests show the plagioclase to be approximately 100% albite. The quartz is unusual in that it contains only very few fluid inclusions; it shows slight to moderate strain shadows.

The tourmaline is mainly in large black masses, occasionally exceeding 5 cms. in cross-section. It is pleochroic from blue-black to pale purplish-brown. Near-basal sections of large crystals show marked, irregular streakiness and zoning, the colour ranging from dark bluish-grey to grey-brown. Tourmaline bordering the garnet is pleochroic from bluish-black to pale nigger-brown.

The apatite is sometimes in green, granular masses, but it more often shows a layered structure in which saucer-shaped layers 1 to 1·5 mm. thick alternate with similar ones of albite. Apatites as much as 3 cms. across have been met with. The R.I. is 1·64, indicating it to be a fluor-apatite with a small admixture of the chlor-apatite molecule.

A secondary mineral, buff or pale brown, as seen in the hand-specimen is associated with the apatite; this gives a strong reaction for phosphate, but does not seem to be completely soluble in hot 1 : 1 HNO_3, though effervescence takes place during solution. In some parts of the specimen an apparently similar mineral is white and somewhat drusy. In other parts there is a soft, waxy, buff-brown to reddish buff secondary substance which gives a reaction for phosphate but is probably a mixture, since it is only very slightly soluble.

As seen in the microscope slide, this secondary mineral is usually observed as a shell bordering and embayed into apatite; most of this is light brown to buff in transmitted light, but parts of it are light greenish-brown, while a little is rust-brown from iron oxide staining. From chemical and optical tests it appears that this substance is dahllite or a closely similar mineral. Closer microscopic examination reveals the fact that the light brown parts are yellowish-white in vertical reflected light; they are almost isotropic but sometimes show spherulitic structure; the light greenish-brown parts, on the other hand, are neutral in reflected light and show aggregate polarization. Perhaps this difference explains the incomplete solubility of the substance. Some small grains of apatite are almost completely replaced by these minerals. An unidentified, colourless, biaxial negative mineral of low D.R. and R.I. slightly higher than apatite is occasionally found with the dahllite.

The garnet is a pale pinkish-buff in transmitted light. It may be in masses up to 3 cms. in diameter, but usually in very irregular grains, often bordered by isolated grains or a narrow rim of poikilitic tourmaline which sometimes encloses a little microcline. A few small grains of garnet are embedded in the feldspar.

We are indebted to B. R. Lewis for a chemical analysis of this garnet as stated herewith:—

SiO_2	35·0	CaO	0·8
TiO_2	0·1	MgO	0·4
Al_2O_3	22·1	MnO	29·5
FeO	12·6		
		Total	100·5

This, approximately, represents an isomorphous mixture of 2 Spessartite [$3(MnO).Al_2O_3.3(SiO_2)$] molecules with 1 Almandite [$3(FeO).Al_2O_3.3(SiO_2)$] molecule.

PEGMATITIC DRAVITE-QUARTZ-ALBITE ROCK ([6017]: The Big Needle

This occurs as an irregular local schlier in albite-leucogranite. It is a porous rock consisting of a clear nigger-brown to yellow-brown mineral (often in striated crystals typical of tourmaline) which is apparently dravite, saccharoidal quartz and semi-saccharoidal albite. Little or no feldspar is associated with the dravite which occurs in separate, medium-grained pockets, with a little associated quartz. Evidently the quartz and dravite have replaced the feldspar. Tiny cavities are particularly abundant in the parts of the rock which have been replaced, and some of them are about 1 cm. long; small crystals of quartz (sometimes double-ended) and occasional crystal of dravite can be seen projecting into these spaces.

Microscopic Observations—Optical tests on the brown mineral show that it is uniaxial negative with its maximum R.I. approximately equal to 1·62 and the minimum slightly less than 1·61. The lower limit of R.I. seems a little too low for any known tourmaline, and the higher is certainly too low. The D.R. of the mineral is probably about 0·013, and it is pleochoic in shades of pale buff. These data correspond most closely to those given for dravite, but there must be some important modifications in this case to give rise to the differences mentioned. In a few places the dravite is bordered by small patches of a grey-blue to very deep cobalt-blue, pleochroic mineral which appears to be tourmaline, and since these patches are in optical continuity with the larger masses, it seemed reasonable to assume that the latter, also, are a variety of tourmaline. Undulose extinction suggesting composition zoning is a feature of it.

In order to make certain of the nature of this mineral a partial analysis was kindly undertaken by Mr. Lewis, who found it to be composed of 12·8% MgO and 38·8% SiO_2. Its identity as dravite is thus confirmed.

Optically continuous dravite is extensively riddled with inclusions of quartz, and the contact between the two minerals is extremely irregular.

Intruded Rocks

HORNFELS

METASOMATIZED SCHLIERIC QUARTZ-ALBITE-ZINNWALDITE-HORNFELS [6015]: Tourmaline Hill

A fine to medium--grained contact rock from the Tourmaline Hill Locality, consisting of patches and schlieren of brownish-grey mica embedded in a matrix of white feldspar and quartz. The rock, particularly in the micaceous parts, is distinctly miarolitic.

Microscopic Observations—The principal minerals are mica, fresh plagioclase and quartz. In grain-size the feldspar is very variable; some bands average 0·25 mm., while others average about 2 mm. The mica is associated with quartz and a little plagioclase; large irregular grains of the former usually form a matrix for numerous flakes of mica.

In the feldspar, which is subhedral, the symmetrical extinction is 17°; in its (001) cleavage-flakes $\gamma' = 1{\cdot}53^5$ and $\alpha < 1{\cdot}53^5$; thus it is pure albite. Twinning is often abruptly interrupted within a crystal and is usually very coarse; both opaque and clear granular inclusions are common.

The plagioclastic bands are completely free from quartz, but the quartzose and micaceous areas contain a little feldspar, usually included in the quartz; the latter also contains minute rod-like grains of a greenish-white mineral, apparently tremolite. Also an occasional grain of calcite.

Pleochroism in the mica is from light buff to off-white, and pleochroic haloes are often developed. The β refractive index is approximately 1·57 and the interference figure of cleavage-flakes is biaxial with a very low optic axial angle, 2V about 10°. Examined spectroscopically lithium was found to be present in large amount. Thus this mica is taken to be zinnwaldite.

A number of accessories is present, all in small amount. Pinkish-white fluorite is, perhaps, the most abundant; some isolated grains occur, but most of it fills cavities and lines vughs; no crystal forms are visible. Next there is brownish-yellow chalcedony, and its mode of occurrence is similar to that of fluorite, with which it is often associated; its R.I. is considerably less than that of balsam, and part-spherules are often developed. A few grains of tourmaline (pleochroic from brownish-grey with a bluish tinge to yellowish-grey), of apatite and black iron ore are also present. Finally, there is a colourless, uniaxial positive mineral of good relief, which shows sieve structure in one or two instances.

Specimen [5152] is another example of metasomatized contact rock from Tourmaline Hill, very like [6015] but with relatively more abundant mica. Some of the miarolitic cavities are about 1·5 cm. across.

In the microscope slide mica plates of hexagonal outline are not uncommon, and some carry needles of rutile. The feldspar is albite ($X' \wedge (001) \perp \mathbf{Z} = 22°$); one or two grains contain granular, apparently residual, microcline with many dusty inclusions, and a few carry a little mica. Small, well-shaped crystals of tourmaline occur occasionally in feldspar. Sporadic grains of zircon are found in the zinnwaldite, where they cause pleochroic haloes. Finally, the uniaxial positive mineral of high relief and second order interference colours present in [6015] is more abundant here: it is quite formless and usually shows marked sieve structure, the included mineral being zinnwaldite.

Albite-tourmaline-biotite-quartz-hornfels [5841]: The Pinnacle

A schlieric contact rock from the Pinnacles locality. It is of variable colouring and grain-size and is constituted of greyish white feldspar, biotite, and black tourmaline, the latter usually in grains about 3 mm. across.

Microscopic Observations—In a confused mass of albite of fine but variable grain-size are set larger grains of biotite, tourmaline and anhedral quartz. The albite is fresh and carries very numerous dusty and granular inclusions. Many grains of feldspar are embedded in the quartz.

The mica, which occasionally includes grains of rutile, is pleochroic from yellow-brown to yellowish white; pleochroic haloes, though present, are scarce. Some of the books are bent. It appears to be phlogopitic.

Zoning is a feature of the tourmaline; the cores are yellow-brown and the outer parts olive-green. Some grains which are entirely of the latter colour are present; these and the zonal shells were obviously formed at a late stage in crystallization. They are pleochroic from olive-green to very pale pink.

Accessories are ragged grains of very cloudy apatite, small quantities of grey sphene, black iron ore, calcite and zircon.

ALBITE-TREMOLITE-CALCITE-SPHENE-HORNFELS [6026]: Tourmaline Hill

A mottled rock consisting of oval (about 3 mm. x 2 mm.) masses of a light ash-grey to a somewhat warmer-toned substance embedded in a cementing aggregate of faintly greenish-grey amphibole with lustrous cleavage faces.

Microscopic Observations—In section the oval areas of the hand-specimen are faintly brownish. They consist of very fine-granular aggregates of a number of minerals. The most abundant of these is difficult to identify, but it appears to be untwinned plagioclase, apparently albite, though its colour in the hand-specimen suggests scapolite; it is so very fine-grained and dusty as to be difficult to recognise. This then is a spilositic development, but its analogy with [5923] and [6106] suggests that it may have passed through a preliminary stage of scapolization during the process of thermal metamorphism.

Scattered through this "matrix" of what appears to be plagioclase are abundant minute grains of calcite and brown biotite, and also much coarser ragged individuals and sheaf-like groups of pale grey-green actinolite. These are different from but sometimes mingled with or bordered by a colourless or greenish-white iron-poor actinolite which forms the cementing aggregate so conspicuous in the hand-specimen. In this latter amphibole $Z \wedge C =$ about 18° and the sign is biaxial negative with very high optic axial angle; it contains a number of green pleochroic haloes, which border grains (probably sphene) of high R.I.

Associated with the main masses of actinolite are small amounts of sphene, calcite, apatite and clear albite or quartz; the sphene is interesting in that it is strongly pleochroic like that from the Giant's Head itself [6010]; its colour-change is from wine-red mottled with light brown, to buff; the mottling shows variability of composition. Flakes of a light-coloured chlorite are also associated with actinolite masses and with the groundmass.

ALBITE-TREMOLITE-CALCITE-HORNFELS [5922]: Tourmaline Hill

A mottled, medium-grained, semi-gneissic, calc-silicate rock composed of light silver-green tremolite, flesh-coloured carbonate, white albite and a few unevenly distributed flakes of dark mica. Pore-spaces are not uncommon in the calcitic areas. The albite and carbonate are in discontinuous wavy bands and also in clots.

Microscopic Observations—The minerals are irregularly distributed. The whole "matrix" consists of fresh, fine-grained, twinned albite, which contains very many inclusions of granular, light green tremolite, often as stumpy rods. At times these inclusions are so numerous as to take up as much space as the host itself. Symmetrical extinction in the feldspar is 17° (100% Ab).

Embedded in the albite are irregular pockets, often elongated, of colourless tremolite and calcite. These two minerals are very closely associated and intergrowths of them are common, so much so that the amphibole sometimes encloses more than its own volume of carbonate. This shows that recrystallization took place very rapidly. Grains of albite also are frequently present in the same host. The tremolite, in which $Z \wedge c =$ about 20°, is in ragged-bladed crystals often showing a radiating structure when grouped. Odd grains of quartz are present; this indicates that the MgO has all been used up in the formation of tremolite, leaving none for dolomite.

Accessories are present in very small amount only; they comprise sphene and rutile, often intergrown phlogopite (pleochroic from pale brownish-green to very pale yellow-green), a grain of epidote and a speck of goethite.

SCAPOLITE-BIOTITE-(VESUVIANITE)-HORNFELS [6022]: Tourmaline Hill

A grey-black rock consisting mainly of oval grains of waxy scapolite about 2 mm. across. Fine-grained dark mica and minute grains of pyrite can be dis-

tinguished by the aid of a lens. Occasionally the pyrite occurs in larger masses. On the weathered (but unabraded) surface the scapolite stands out in relief as knots, between which are depressed areas rich in mica; in these areas there is also in relief a relic of fine-scale sedimentary banding.

Microscopic Observations—In section, when compared with specimen [5923], this rock shows important differences warranting special description. It consists predominantly of oval, rounded and irregular grains of marialite-rich scapolite, which are mottled under crossed nicols and have no relatively clear margins (contrast [5923]). Although these grains show no pronounced optical orientation, those which are elongated grains have their long axes parallel. As in [5923], fine-grained, pale brown mica, probably phlogopite, occurs between the scapolite grains, but it is by no means as well segregated as in that rock; much scapolite relatively free from mottling but showing undulose extinction is associated with it.

The relics of sedimentary laminae noted in the hand-specimen show up in section as closely-spaced, apparently slightly carbonaceous biotite-rich bands, alternating with others rich in scapolite grains.

Forming inclusions in the scapolite are pale brown mica, clear quartz, a little pale green tremolite, calcite, pyrite, grey and brown sphene in small, irregular grains and rare magnetite and tourmaline (pleochroic from blue-grey to bluish-yellow). Zircon, in elongated crystals, is very rare. Very strong pleochroic haloes around minute grains have developed in some of the mica.

Apart from scapolite, the most interesting mineral in this rock is vesuvianite; it occurs rather sparsely as euhedral to irregular grains associated with the mica. The mineral is traversed by closely-spaced cracks which render it grey in transmitted light, though it is quite clear between the cracks. Its relief is high.

The rock is a scapolite-biotite-(vesuvianite)-hornfels, derived by metasomatic replacement from an impure, slightly carbonaceous limestone, which was thoroughly worked over by sodic solutions.

Scapolite-biotite-hornfels [6021]: Tourmaline Hill

This rock closely resembles [6022]. Microscopic examination reveals the following differences.

The scapolite grains are notably elongated, and there is probably a more marked parallelism of their *c*-axis. Mottling is often stronger in certain well-defined parallel bands which may represent channels along which solutions travelled. These bands are parallel to the original bedding. These peculiarities suggest relationship to varying porosity and chemical variation in the original sedimentary laminae.

Carbonaceous inclusions are almost entirely absent, but, as in specimen [6022], the elongated scapolite grains lie parallel to whatever banding there is.

The mica is a little more plentiful and is more strongly segregated. Carbonate (calcite or dolomite) is much more abundant and usually occurs in distinct pockets and veinlets. Tremolite and vesuvianite are absent and iron-ore is less plentiful.

A few apatite inclusions are found in the scapolite; inclusions of tourmaline, as stumpy prisms, pleochroic from brown, bluish-brown or greenish-brown to yellowish-white are relatively more abundant in the scapolite of [6021].

Scapolite-tremolite-biotite-hornfels [5923]: Tourmaline Hill

A medium-grained rock consisting largely of a mass of dark grey grains of scapolite about 2·5 mm. across; their cleavage faces are dull and waxy, due to the presence of abundant inclusions. Occupying the spaces between these are small laths of greenish-white tremolite and plates of brown mica.

Microscopic Observations—Polygonal and oval porphyroblasts of scapolite make up the bulk of the rock (pl. iii, fig. 3). Several features of this mineral are

of interest. It contains very numerous inclusions of quartz and pale biotite and small quantities of grey sphene and of calcite; small tourmaline needles, pleochroic from greenish-brown to a faintly greenish tint are also present, but they are very rare. A narrow marginal zone of the scapolite grains is often relatively poorer in inclusions; however, this zone shows up most clearly not for that reason, but because of its lower double refraction as compared with that of the inner parts of the grains, which are further distinguished by being strongly mottled under crossed nicols—so much so that they have the appearance of being broken up into a mosaic; this mottling suggests non-uniformity of composition (see below) and is undoubtedly connected with the formation of the rim of different composition. Nearly all parts of any one grain extinguish simultaneously. In the slide examined the range of interference colours to be observed in certain mottled areas is from blue to yellow; the lower colours both here and in the marginal zone are undoubtedly due to the gradual partial replacement of the original scapolite by a more marialitic one, a process which probably took place as more and more soda-rich material found its way out from the igneous intrusion to the country rock, which was probably an impure magnesian limestone.

Forming pockets between the scapolite grains are aggregates of bladed tremolite, fine-grained biotite and calcite, together with small amounts of granular grey sphene, apatite and rare haematite. A little scapolite is also mingled with these minerals.

The tremolite is pleochroic in white and greenish-white, and green pleochroic haloes around grains of sphene are not uncommon therein. A little tremolite is also embedded in the scapolite grains, but here it has developed a considerably stronger green colour, and the grains are much more irregular. Pleochroism in the biotite (phlogopitic) is from light rust brown to pale yellow; the mica in the scapolite has a somewhat greenish tinge.

SCAPOLITE-BIOTITE-HORNFELS [6106]: Tourmaline Hill

This is closely related to [5923] but with more abundant interstitial micaceous base between the richly scapolitic ovoids. Obvious tremolite is absent. A relict structure based on the original planes of deposition is a feature of the rock.

SCAPOLITE-BYTOWNITE-PHLOGOPITE-HORNFELS [5924]: Giant's Head Locality

A dark grey, massive, medium-grained rock consisting of very dull scapolite containing clots of dark mica.

Microscopic Observations—The texture is typically decussate. No relic of directional structure remains. The essential minerals are scapolite, plagioclase and phlogopite, or pale biotite. The first of these predominates greatly and is in extremely irregular grains with sinuous and sutured boundaries; only rarely is there any sign of subhedral outline. Judging by its D.R., this mineral is probably somewhat more meionitic than that in the other rocks described. By contrast with specimens [5923] and [5110] the scapolite is sometimes more meionitic near its borders; this is indicated by an increased D.R., generally though not invariably, unnoticeable when the mineral is in contact with plagioclase or mica.

When fresh the plagioclase is clouded brownish-white by very minute, extremely concentrated, unidentified inclusions. Measurements with the universal stage gave the maximum extinction in the symmetrical zone as 52°, which corresponds to $Ab_{18}An_{82}$. The plagioclase is extensively sericitized and scapolitized; the sericitization seems always to have extended in advance of the scapolitization. A dark mica is not uncommonly associated with the other two minerals in the feldspar.

A mica which appears to be phlogopite is pleochroic from very light brown to yellowish-white; occasionally a little carbonate is associated with it. Besides occurring in clots, it forms rather abundant fine inclusions in the scapolite.

The accessories are anhedral black iron-ore, often bordered by pale leucoxene, grey-green pleochroic actinolite and rather rare apatite. The iron-ore and amphibole are fine-grained and rather irregularly distributed in the scapolite; the second is confined to the scapolite, but the first is also associated with the mica-clots, and in these cases it is subhedral to euhedral. All sections of what is referred to as apatite are isotropic; this may be a matter of chance, or else the mineral may be hibschite or plazolite; however, the frequent occurrence of apatite in other rocks of this locality is evidence in favour of this also being apatite.

TREMOLITE-SCAPOLITE-HORNFELS [6014]: The Needles

This rock consists of a felted aggregate of light greenish-grey, silky tremolite in which are embedded grains of off-white scapolite 1 to 2 mm. long. In a more coarsely crystalline pocket the tremolite crystals approach 1 cm. in length and 0·75 cm. in breadth. The ratio of amphibole to scapolite is about 2·5 : 1.

Microscopic Observations—The microscope section shows a closely-interlocking mass of bladed, colourless tremolite crystals interspersed with subhedral to anhedral (especially in basal and near-basal sections) grains of scapolite; a little sphene is also present. The amphibole is often in sheaf-like and radiating bunches and the grains present are roughly of two sizes, namely 2 mm. and 0·5 mm.; its maximum measured extinction $Z \wedge c = 18°$. Pale green pleochroic haloes are occasionally seen around the sphene, especially the smaller grains, when it is embedded in tremolite.

The scapolite is in grains and resembles plagioclase in ordinary light. Under crossed nicols mottling is sometimes seen, and the central parts of the grains are richer in meionite than are the outer shells. Often this mineral has a brownish stain, and occasionally it shows some alteration to sericite. In one crystal a few small grains of calcite were seen.

The sphene is in irregular grains and is pleochroic from brown to yellowish-brown. It closely resembles the sphene of rock [6010] of Giant's Head.

CALC-SILICATE MARBLES

TREMOLITE-ALBITE-PHLOGOPITE-MARBLE [5922]: Tourmaline Hill

A faintly greenish-grey and white patchy rock composed of tremolite, calcite, albite and a little brown mica.

Microscopic Observations—The original marble has been completely recrystallized and the minerals developed contain abundant inclusions, giving the slide a cloudy appearance as viewed under ordinary light. Taken in order of abundance the minerals present are the following.

Albite with a composition about $Ab_{97}An_3$ and in quite fresh condition is present in small subhedral to anhedral crystals. It is clouded owing to inclusions of a dusty nature and others of minute tremolite.

Tremolite is plentifully developed, especially in pockets where it forms radiating sheaf-like structures. Calcite is plentiful; some occurs intergrown with the tremolite.

Accessory constituents are phlogopite, sphene and rutile; the latter quite rare.

GLAUCOPHANE-ALBITE-SIDERITE-MARBLE [6029]: Tourmaline Hill

A medium-grained rock consisting of yellow-buff carbonate minerals containing patches very rich in blue amphibole.

Microscopic Observations—In a matrix of medium-grained calcite are set grains and whisks of blue amphibole, anhedral to subhedral albite and some poorly-developed rhombs of what is probably siderite.

The amphibole often includes large quantities of calcite; occasionally it contains albite and a few granules and rods of black iron ore. $Z \wedge c = 26°$; $X =$ bluish-white, $Y =$ pale blue with a purple tinge, and $Z =$ pale blue-green; the double refraction is about 0·03, much higher than for normal glaucophane, and the mineral is probably so-called abnormal glaucophane of Winchell (15), which may be Naurodite of Knebel (7). Anomalous brown interference-colours and mottling between crossed nicols are common.

The albite contains granules of fine amphibole, dark specks, irregular fluid inclusions and some grains of calcite. In numerous places it is being replaced by a mottled feldspar resembling anorthoclase.

The accessories are quartz, haematite in mossy patches, a few grains of rutile, and light brown mica pleochroic from golden-brown to light golden-yellow.

The calcite is rich in fluid inclusions. The quartz is in very irregular, interstitial grains; it contains some albite, calcite and blue amphibole. Its presence indicates that, very probably, no dolomite is to be expected here, for its mode of occurrence (shape, inclusions) is such that there is no doubt that the whole rock has been re-constituted; amphibole has been formed, and there was obviously not sufficient MgO to form more. Conditions were not suitable for the formation of wollastonite, olivine or monticellite.

SIDERITE-ALBITE-GLAUCOPHANE-MARBLE [6028]: Tourmaline Hill

A medium-grained, blue-grey rock consisting of calcite and related carbonate minerals, patches of white feldspar, a little black mica and grains and fibres of a blue amphibole. Occasional minute specks of pyrite are visible.

Microscopic Observations—In an irregularly distributed base made up of calcite and albite of fine but variable grain-size are set abundant and imperfect rhombs of siderite, ankerite or a similar mineral, subhedral grains of albite, and small quantities of other minerals. A little albite may be included in the rhombs; they also carry small amounts of goethite or limonite.

The fine-grained albite often occurs in clots, though it is sometimes mingled with calcite. These albite clots, especially, are crowded with dusty and granular inclusions and also contain small grains of calcite; sometimes they are made up of extremely small grains (0·015 mm.), but their average diameter is 0·03 mm. In many cases the coarser plagioclase is being replaced by anorthoclase or orthoclase. This feldspar has a lower R.I. than that of albite and a mottled appearance under crossed nicols.

The amphibole is present in less quantity, only about 2%, than is suggested by the appearance of the rock in hand-specimen. Apart from being interstitial generally, it is often crowded in a thin layer of minute grains round the borders of rhombs of carbonate. Its pleochroism is similar to that of the abnormal glaucophane in rock [6029]. Altogether it is very like that mineral. $Z \wedge c$ was measured as 23°, but may be more. Many grains do not extinguish at all—they mostly change from an anomalous brown through greenish-yellow to blue-green on rotation between crossed nicols.

The most abundant accessory is mica. It is pleochroic from golden-brown to light golden-yellow; bent flakes are not uncommon.

There are also present black iron ore in granules and rods, sparse haematite and some small, scattered grains of rutile. Quartz is not present.

ALBITE-BEARING, DOLOMITIC MARBLE [6027]: Tourmaline Hill

This is a faintly brownish-white, fine-grained rock, composed largely of carbonate minerals. Small patches of white feldspar are visible on a cut surface, while black grains of tourmaline are scattered throughout the specimen.

Microscopic Observations—Broadly, the rock consists of a matrix of carbonates in which are embedded clots of albite. Both calcite and dolomite are present; the latter occurs in clear, subidiomorphic rhombohedra about 0·2 mm. across, embedded, often poikilitically, in much coarser calcite, which is really interstitial in development, and shows no crystal boundaries. The most obvious distinction between the two carbonates is that the calcite is murky with inclusions, and it is this feature which makes it so easy to see the subhedral outlines of the dolomite crystals.

The albite is almost pure, as shown by a symmetrical extinction of at least 16·5°; confirmation of this result is found in its positive sign and in the fact that $X' \wedge (001) \perp Z = 22°$. It occurs both as shapeless clots and as masses which have definite rhombic and tabular shapes, strongly resembling those characteristic of feldspar crystals. The albite is largely confined to these areas, and is a fine-grained aggregate in their central parts, but coarser toward their margins. A little tourmaline, pleochroic from deep brown to buff, is associated with the albite aggregates.

Occasional grains of subhedral to euhedral quartz are embedded in the matrix, but this mineral does not appear to be associated with the albite aggregates. In one or two cases, however, small albite crystals are embedded in the quartz.

Minute grains of a dark red-brown mineral resembling rutile are present. Phlogopite or pale biotite is present, but rare.

The fact that quartz is associated with dolomite suggests that metamorphism in this rock and probably in the whole intrusion, took place at a very low temperature, because no forsterite has been formed. There is no evidence in the field or in the slide that the failure of SiO_2 to react with MgO, in this case at least, was due to high confining pressure; non-carbonate rocks in the vicinity of this intrusion have been scarcely affected by metamorphic processes.

A partial chemical analysis of this rock gave the following percentage results. Insoluble 23·14, $FeCO_3$ 2·96, $CaCO_3$ 54·28, $MgCO_3$ 20·04; total 100·42. In arriving at this result the CO_2 was not determined but is that calculated assuming the soluble bases to be all carbonates.

ALBITE-BIOTITE-MARBLE [6025]: Tourmaline Hill

A mottled, medium-grained rock consisting of white carbonate minerals in which are embedded dark grey aggregates of very fine-grained albite and biotite. Octahedra of pyrite, stained red with a thin coat of haematite are quite prominent.

Microscopic Observations—The carbonate and silicate parts of the rock are more or less sharply differentiated in section (pl. iii, fig. 4). Very irregular patches of the former, whose average grain-size is about 0·3 mm., are embedded in a very fine-grained matrix consisting mainly of albite; the two parts are present in about equal amount, with the albite probably in slight excess. In section, in contradistinction to the hand-specimen, it seems logical to refer to the albite as the matrix.

Included in the carbonate tracts are small amounts of albite and biotite, while the siliçeous areas are composed of albite with subsidiary amounts of biotite and fine-grained carbonate. The material of the feldspar was probably introduced into the limestone during the process of metamorphism; at the same time, complete reconstitution probably took place, for the biotite tends to be most abundant at the edges of the carbonate, which seems to indicate that the carbonate recrystallized in segregated areas, while any impurities therein were withdrawn and contributed to the formation of biotite.

In the case of some of the larger subhedral grains of the feldspar, its composition was determined as very close to Ab_{100}. The albite is quite fresh and contains minute, irregularly distributed inclusions of biotite.

The subhedral shape of some of the grains of carbonate mineral suggests that dolomite is present; colourless to pale green tremolite is only very rarely developed: it occurs in minute grains in what appears to be dolomite.

Quartz is very rare in the slide, and only one grain was seen in the hand-specimen.

The mica is pleochroic from light brown to very pale yellow and, therefore, phlogopitic. It occasionally contains pleochroic haloes; minute clots of leucoxene are also embedded therein.

Pyrite, which is always in the grey albitic areas, is usually bordered by haematite and magnetite.

Numerous, small, irregular, dark grey aggregates of sphene-granules are found, particularly in the albitic areas and at the junction of these with the carbonate.

TREMOLITE-ALBITE-BIOTITE-MARBLE [6105]: Tourmaline Hill

This rock is closely related to [6025] but contains less carbonate minerals. It is grey and very similar in general appearance to the preceding, but differs in being loaded with ash-grey prisms of tremolite. These, mainly concentrated along the bedding planes, reach 1 cm. in length and 1·5 mm. in cross-section.

CONCLUDING OBSERVATIONS

From the foregoing observations concerning these intrusive masses it will be observed that they are in the nature of cupola summits above the general plutonite mass of a large scale granitic intrusion into the thick series of sediments deposited during Proterozoic and Cambrian times in the great geosyncline of South Australia. They represent the summits of active upward migration of magmatic gases and solutions.

The igneous rocks of these cupolas are essentially leucocratic, quartz-orthoclase (orthoclase, microcline and microperthite)-albite (sodaclase) rocks. Rarely if ever is the plagioclase as calcic as oligoclase; in very many, the sodaclase is in excess of the orthoclase. Femic minerals are absent to rare. In Johannsen's classification (6) they range from alaskites to leuco-sodaclase-granodiorites with exceptional occurrences just coming into the range of leucogranites as defined by him. However, for our purpose, the broader use of the term leucogranite as defined by Hatch and Wells (4) has been adopted in this contribution. Whether gravity separation of earlier crystallized femic minerals has played any notable part in determining their absence is not obvious. There is, on the other hand, clear evidence of large scale migration of soda, silica, chlorine, boron and potash into the surrounding rocks, enriching them in such minerals as albite, scapolite, mica and tourmaline.

Soda-rich differentiates of granite intrusions of this same age have been recorded elsewhere in South Australia, for example, the soda-aplite (see table, p. 32) of Port Elliot described by Browne (2) and the albite of Cape Willoughby described by Tilley (14). The latter contains local concentrations of tourmaline which are closely paralleled in some of the Umberatana leucogranites.

For the most part these cupola rocks of Umberatana differ in texture from normal granites. They bear evidence of having crystallized from magmatic liquids abnormally rich in volatiles resulting in pegmatitic, aplitic and even spongy textured crystallizations with abundance of liquid and gaseous inclusions in the feldspar and quartz. The summits of the cupola masses are crystallizations of

this kind, but a transition in texture towards normal granite is noticeable in more deeply exposed areas.

Increasing abundance of microcline is a feature of the deeper zones. In portions of the marginal areas of the intrusions, microcline is in process of replacement by albite. Bowen's (1) explanation for such replacement may be applicable here. He states: "Of the two alkali metals, soda and potash, the latter forms the more volatile compounds. As loss of vapour proceeds, the liquid is enrched in soda more than potash. Eventually potash feldspar becomes unstable in contact with the liquid and is replaced by albite."

It would appear that the operation of the mechanism responsible for the transfer of soda, silica, etc., into the surrounding sediments has been responsible also for the abnormal enrichment in soda of the cupola rocks, the transfer to the latter site taking place in ascending gaseous and thermal fluids and not as a gravity separation of already crystallized constituents. Accessory minerals in the leucogranite are very irregularly distributed, but in some places there are notable concentrations of tourmaline, apatite, sphene and garnet.

A notable feature of the metamorphic aureole is its richness in albite and scapolite. Earlier formed scapolite in the hornfelses is unusually meionitic with later accessions and marginal zones richly mariolitic.

Albite is almost ubiquitous in both igneous and metamorphic rocks. The only group in which it does not figure is the scapolite-bearing rocks. But in one hornfels specimen albite is replacing what appears to have been earlier-formed scapolite.

The occurrence of glaucophane (Naurodite (?)) in the hornfelses is also a matter of special interest.

A common feature of the intruded sediments at their contact with the intrusions is their conversion to dark phlogopitic biotite and brown zinnwaldite bearing hornfels, often containing notable amounts of tourmaline; in one case scapolite is a constituent of this zone.

There is ample proof that the mineral transformations evidenced in the hornfels were effected at a very low temperature. This is attested [6027] by the persistence of quartz even in the presence of dolomite.

SUMMARY

Attention has been drawn to the occurrence near Umberatana of the exposed tips of a number of granitic summit cupolas of an early palaeozoic plutonite intrusion. The cupola rocks are remarkably free from femic minerals and are richly sodic with subordinate potash content. At a late stage in their consolidation much of the potash feldspar was replaced by albite. At that time the residual magmatic liquids were highly charged with volatile constituents rich in soda, chlorine, boron, etc.

There is clear evidence that these gases and solutions, containing also potash displaced and eliminated from the cupola rocks, permeated the intruded sediments, some of which were dolomites and limestones. In the hornfels of the metamorphic aureole, dependent on material thus introduced, are much albite, scapolite, phlogopite, as well as orthoclase and tourmaline. Low temperature conditions prevailed during the formation of the hornfels.

Among the more important accessory minerals encountered in the igneous rocks are tourmaline including dravite, sphene containing traces of rare earths, fluor-rich apatite and manganese-rich garnet. Zinnwaldite occurs in the contact zone. Dahllite is recorded in the summit pegmatite of Tourmaline Hill.

Fig. 1

Fig. 2

Fig. 1

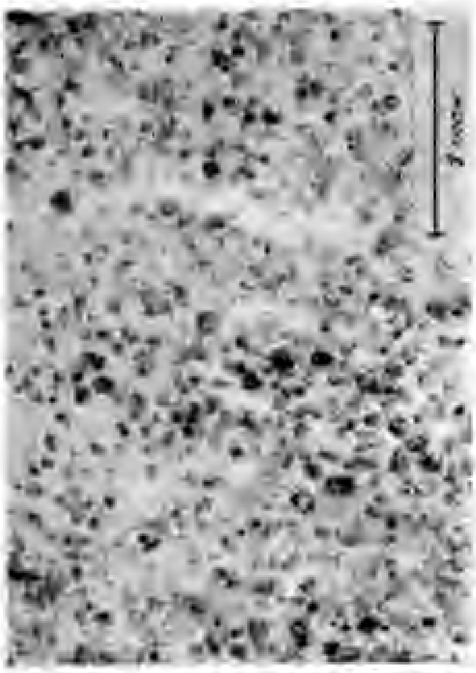


Fig. 2

Fig. 3

Fig. 4

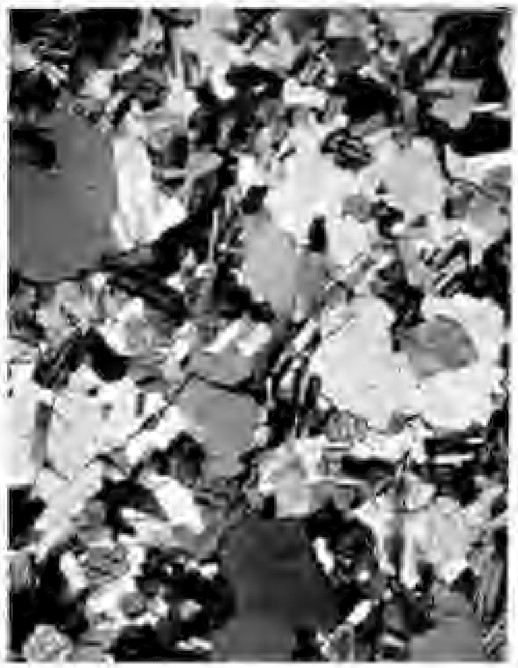


Fig. 1

Fig. 2

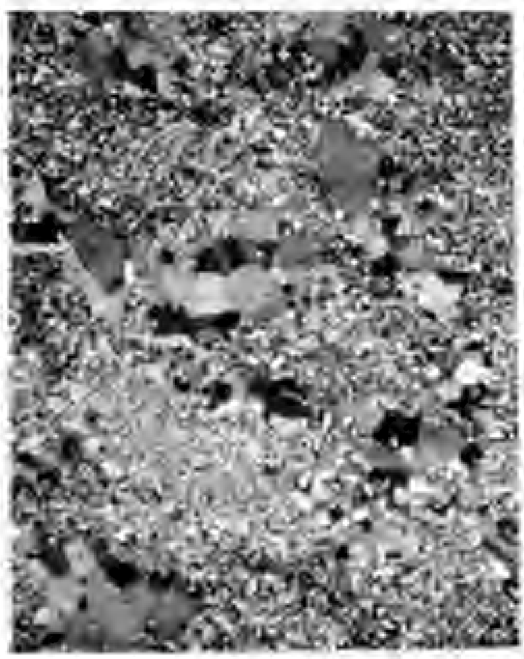


Fig. 3

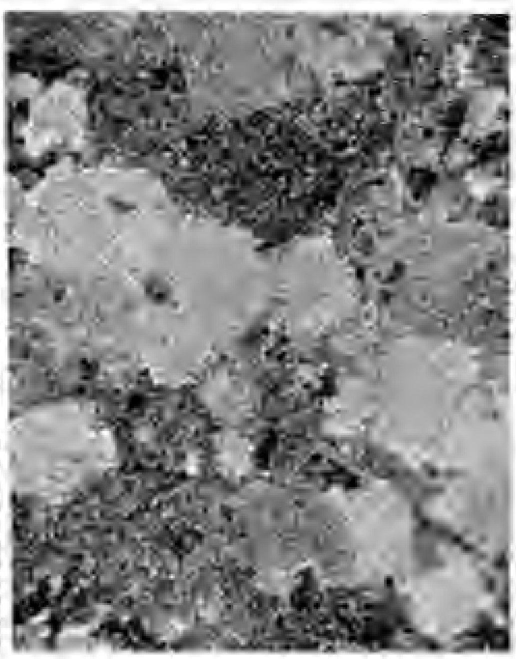


Fig. 4

ACKNOWLEDGMENTS

We take this opportunity to thank Mr. G. A. Greenwood, of Mount Searle, for drawing our attention to The Needles and The Pinnacles-Sitting Bull occurrences, and both him and Mr. R. C. Sprigg for assistance in the field and in an examination of all the areas. We are indebted to Mr. L. W. Treloar, of Umberatana, for hospitality, and to R. G. Thomas and A. R. Alderman for assistance during a preliminary investigation of the Giant's Head and Tourmaline Hill areas undertaken by one of us some years ago.

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Plate I

Fig. 1 The Little Needle observed from the south-south-west. The Big Needle is behind the shoulder of the slope on the left.

Fig. 2 A close view of the upper portion of the Giant's Head outcrop.

Plate II

CORRIGENDA

Arising from the absence of both authors at time of final proofing.

P. 22 line 18, p. 35 line 19, and p. 37 line 21, for "schliers" read "schlieren".
P. 23 line 30, for "(9)" read "(11)".
P. 25 lines 4 and 21, for "pneumatolitic" read "pneumatolytic".
P. 26 line 9, p. 32 line 6, and p. 44 line 48, for "whisps" read "wisps."
P. 29 line 34, after "white" insert "mica".
P. 32 and p. 34, for "W. T. Dalwood" read "T. W. Dallwood".
P. 36 line 15, for "interstitial" read "intersertal".
P. 39 line 12, for "schlier" read "schliere".
P. 40 line 2, for "α" read "α'".
P. 41 line 19, for "green" read "pale green".
P. 41 line 47, transpose comma after "rutile" to after "intergrown".
P. 44 line 27 should read, "pleochroic from light maroon to buff".
P. 48 line 7, for "enrched" read "enriched".
P. 48 line 13, in place of "in ascending" read "through the agency of ascending".
P. 48 line 48 insert brackets before and after "including Dravite" and "containing traces of rare earths".

CONTRIBUTIONS TO OUR KNOWLEDGE OF THE AUSTRALIAN TORTRICIDAE (LEPIDOPTERA)

BY A. JEFFERIS TURNER (READ 10 MAY 1945)

Summary

Fam. TORTRICIDAE. I use this family name in a broad sense to include the four families into which it has been divided by Meyrick. These I prefer to consider subfamilies. The two largest subfamilies, the Tortricinae and Eucosmidae, though natural groups, are not separable by any absolute character, and do not therefore seem entitled to more than subfamily status. The Tortricinae *(sensu lato)* should, I think, be regarded as a branch of the great superfamily Tineoidea.

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Subfam. PHALONIANAE

Genus Heliocosma

The following species of this genus are closely similar, and need careful discrimination. They have been adequately described; but it seems advisable to give their distinguished characters and geographical distribution.

H. exoeca Meyr., 12-16 mm. Forewings without red scales; with a narrow ochreous-grey subterminal fascia. Hindwings white.

North Queensland: Cape York, Townsville. Magnetic Island. Lindeman Island. Also from New Guinea.

H. argyroleuca Low., 15-22 mm. Examples from Mount Kosciusko and Tasmania are much larger than those from other localities. Forewings without reddish scales; terminal area with divergent grey streaks. Hindwings grey-whitish.

Queensland: Brisbane, Dalby, Chinchilla, Warwick, Milmerran, Inglewood, Stanthorpe. New South Wales: Tenterfield, Brunswick Hds., Tabulam, Ebor, Mittagong, Mount Kosciusko (3,500 feet). Victoria: Gisborne. Tasmania: Cradle Mount, Hobart.

H. incongruana Wlk., 12-19 mm. Forewings with reddish markings; terminal area with apical and tornal streaks or spots, sometimes approximated. Hindwings grey-whitish.

North Queensland: Cape York, Atherton. Queensland: Duaringa, Caloundra, Stradbroke Island, Tweed Hds. New South Wales: Ebor, Sydney, Katoomba, Mount Kosciusko (6,000 feet). Victoria: Gisborne, Beaconsfield, Melbourne. Tasmania: Strahan, Tasman Peninsula, St. Marys, Weldborough. South Australia: Mount Lofty.

H. rhodopnoana Meyr., 15-22. Forewings with broadly suffused dark markings; a sharply dentate subterminal line of irregular thickness, sometimes interrupted into spots or streaks. Hindwings grey.

New South Wales: Mount Kosciusko (6,000 feet). Victoria: Mount Buffalo, Gisborne, Melbourne. Tasmania: Cradle Mount, Derwent Bridge, Lake Fenton, St. Helens. South Australia: Mount Lofty. Western Australia: Albany, Denmark, Perth.

Gen. **Choristis** nov.

χωριστις, separate.

Tongue present. Palpi short; second joint broadly expanded above and beneath; terminal joint short, obtuse. Antennae in male thickened, simple. Thorax with a posterior crest. Forewings smooth; 2 from four-fifths, 7 and 8

stalked, 7 to termen. Hindwings with 3 and 4 connate, 5 from middle of cell, 6 and 7 stalked, 7 to costa. Type *C discoplaca* Turn.

CHORISTIS DISCOFLACA Turn.

Trans. Roy. Soc. S. Aust., 1916, 501. *Capua discotypa* Turn., *ibid*, 1916, 510, is a synonym.

Queensland: Mount Tamborine, Tweed Hds., Toowoomba, Carnarvon Range.

Subfam. TORTRICINAE

Paraselena haplopolia n. sp.

ἁπλοπολιος, simply grey.

♂, 16 mm. Head and thorax grey. Palpi 2; grey. Antennae grey; ciliations in male 1. Antennae grey. Abdomen grey-whitish. Forewings narrow, costa slightly arched, apex pointed, termen obliquely rounded; whitish-grey sparsely sprinkled with fuscous; cilia whitish-grey. Hindwings and cilia pale grey.

Tasmania: Bothwell, in March (W. B. Barnard); one specimen.

Gen. **Axioprepes** nov.

ἀξιοπρεπης, goodly.

Tongue present. Head rough-scaled. Palpi ascending, closely appressed to face, reaching vertex, moderately thickened, slightly rough anteriorly. Antennae in male thickened, ciliations in male minute. Thorax with a small posterior crest. Forewings smooth, in male with costal fold; 7, 8, 9 stalked, 7 to termen. Hindwings with 3, 4, 5 widely separate, approximately equidistant, 6 and 7 stalked.

Axioprepes leucozancla n. sp.

λευκοζαγκλος, with white sickles.

♂, 13 mm. Head dark fuscous; tegmina whitish-brown. Abdomen fuscous; tuft whitish-ochreous, towards apex grey. Legs ochreous-whitish; tarsi fuscous with whitish rings. Forewings broad, costa strongly arched, apex pointed, termen scarcely rounded, slightly oblique; costal fold in male narrow, from base to one-third; whitish largely suffused with pale ochreous; a blackish costal streak from base to one-third, where it expands into a round spot; a narrow dorsal streak from near base to one-fourth, followed by several minute strigules; some dark fuscous irroration in basal area; three broad vertical ochreous lines from dorsum ending in the median suffusion; a series of blackish costal dots; an ochreous streak from two-thirds costa obliquely to near termen; an ochreous spot at apex, narrowly prolonged along termen, interrupted by blackish dots; cilia whitish with four blackish bars, on apex, above and beneath middle, and on tornus. Hindwings pale yellowish; cilia pale grey.

North Queensland: Malanda (Atherton Tableland) in September; one specimen.

ISOCHORISTA EUDROSA Turn.

Trans. Roy. Soc. S. Aust., 1916, 503.

I. eutypa Turn., Trans. Roy. Soc. S. Aust., 1925, 46, is a synonym. Queensland: Cape York to Killarney.

Gen. **Anisolepida** nov.

ἀνισολεπιδος, unevenly scaled.

Head rough-scaled. Tongue present. Palpi moderate, porrect. Thorax with a posterior crest. Forewings with raised scales; 7 and 8 stalked; 7 to termen. Hindwings with 3, 4, 5 separate, approximately equidistant, 6 and 7 stalked. Differs from *Isochorista* in the thoracic crest and the raised scales on forewings.

Anisolepida semiophora n. sp.

σημειοφορος, bearing a mark.

♀, 19-22 mm. Head grey-whitish. Palpi 2 and a half; fuscous, upper edge grey-whitish. Antennae fuscous. Thorax fuscous; tegulae whitish. Abdomen fuscous. Legs fuscous with whitish tarsal rings; posterior pair whitish. Forewings dilated posteriorly, costa rather strongly arched, apex rounded-rectangular, termen nearly straight, scarcely oblique; whitish sparsely sprinkled with fuscous; markings dark fuscous; basal patch indicated by a dentate sub-basal line, connected by a slender subcostal line with base of wing; a square costal spot at two-fifths, giving off a crescentic blackish longitudinal line with concavity facing costa, ending on four-fifths costa, preceded by two costal dots and followed by one; a short erect pyramid from tornus; cilia whitish with some grey bars, on tornus dark fuscous. Hindwings and cilia grey.

The male differs as follows: 17-18 mm. Forewings with a slender costal fold reaching to one-third costa; basal patch indicated by a fine fuscous line only; quadrangular spot on costa replaced by two fine parallel lines running to dorsum; no dark crescentic mark in disc; costal triangle suffused, its apex prolonged to tornus.

Queensland: Toowoomba, in September and October (W. B. Barnard); seven specimens. Type in Queensland Museum.

Gen. Pyrgotis Meyr.

Proc. Linn. Soc. N.S.W., 1881, 440, and *ibid.*, 1910, 170.

In Meyrick's original description of this genus he described veins 3 and 4 of hindwings as separate, but very near in origin and 5 closely approximated to 4. In his later reference 3, 4, 5 are described as separate, equidistant, and rather approximated towards base. In reality there is considerable variation in these veins. Meyrick's description is in both cases accurate for some examples, but in others 3 and 4 are connate, and 5 approximated at base as in *Capua*. Notwithstanding, the genus is a good one, sufficiently distinct by its large thoracic crest.

Pyrgotis insignana Meyr.

Proc. Linn. Soc. N.S.W., 1881, 440.

Widely distributed. Queensland: Brisbane, Toowoomba, Stanthorpe. New South Wales: Glen Innes, Sydney, Bulli, Katoomba, Mount Kosciusko. Victoria: Gisborne, Melbourne. Tasmania: Launceston, Deloraine, Cradle Mt, Mount Wellington, Lake Fenton. South Australia: Mount Gambier, Mount Lofty. Western Australia: Albany, Denmark, Waroona.

Acropolitis xuthobapta n. sp.

ξουθοβαπτος, tawny-suffused.

♀, 24 mm. Head and thorax dark fuscous. Palpi 2 and a half; dark fuscous, lower edge whitish. Abdomen grey. Legs fuscous with whitish rings; posterior pair whitish. Forewings suboblong, costa strongly arched to middle, thence straight, apex rectangular, termen straight, rounded beneath; grey, posterior half whitish-grey; markings fuscous; an obscure basal patch, its outer edge oblique from one-fifth costa to tornus, interrupted above middle; cilia fuscous, on tornus grey. Hindwings greyish-tawny; a white costal streak not reaching apex; cilia grey, on dorsum whitish.

New South Wales: Mount Tomah near Mount Wilson, in March; one specimen.

Acropolitis cinefacta n. sp.

cinefactus, reduced to ashes.

♂ ♀, 18-20 mm. Head and thorax dark fuscous. Palpi 1 and a half; dark fuscous. Antennae dark fuscous; ciliations in male nearly 1. Abdomen grey. Legs fuscous with whitish tarsal rings; posterior pair whitish. Forewings sub-oblong, costa moderately arched, apex rounded-rectangular, termen slightly rounded, slightly oblique; costal fold in male reaching one-third, rather broad; grey with slightly raised transverse lines and strigulae; cilia grey with a darker median line.

Queensland: Cunnamulla, in October; nine specimens.

Acropolitis melanosticha n. sp.

μελανοστιχος, with a black line.

♂, 22 mm. Head and thorax grey. Palpi 2; grey. inner surface white. Antennae grey; ciliations in male 1. Abdomen ochreous-grey. Legs fuscous with white rings; posterior pair white. Forewings with costa gently arched, apex rounded, termen obliquely rounded; grey; a black line from base along fold almost to two-thirds dorsum; other markings fuscous; a series of minute costal dots; an oblong costal spot from two-thirds nearly to apex; three or four interrupted lines on veins running to termen; cilia grey-whitish. Hindwings and cilia grey.

Victoria: Birchip, in September; one specimen received from Mr. D. Goudie.

Batodes hemicryptana Meyr.

Proc. Linn. Soc. N.S.W., 1881, 461.

Batodes euryxutha Turn., Trans. Roy. Soc. S. Aust., 1925, 47, is a synonym.

Batodes sphenotoma n. sp.

σφηνοτομος, divided by a wedge.

♀, 26 mm. Head and thorax fuscous. Palpi 1 and a half; fuscous. Antennae fuscous. Abdomen grey. Legs white with fuscous tarsal rings. Forewings dilated posteriorly, costa gently arched, apex rectangular, termen straight, rounded beneath; white with pale grey suffusion, especially in basal area; markings dark fuscous; no basal patch; costa shortly strigulated; median fascia wedge-shaped, broadest on costa, where it extends from two-fifths to three-fifths, anterior edge nearly straight, posterior excavated above middle, apex on two-thirds dorsum; a quadrangular spot on four-fifths costa, from which proceeds a fine line to tornus; a similar parallel line shortly beyond originating in a costal dot; longitudinal streaks on veins between these lines; a terminal line; cilia pale grey. Hindwings and cilia pale grey.

North Queensland: Kuranda, in June; one specimen.

Batodes nimbifera n. sp.

nimbiferus, clouded.

♂, 14 mm. Head and thorax fuscous. Palpi 1 and a half; fuscous, inner surface whitish. Antennae grey annulated with dark fuscous; ciliations in male minute. Abdomen fuscous; tuft grey. Legs grey-whitish. Forewings narrow, costa gently arched, apex pointed, termen very obliquely rounded; costal fold in male narrow, reaching to one-fifth costa; grey-whitish; markings suffused, fuscous; a moderate basal patch, its outer edge from one-third costa to one-fifth dorsum; two or three costal spots beyond middle; some fine dorsal strigulae; a large roundish spot in middle of disc; cilia grey. Hindwings and cilia grey.

Queensland: Stanthorpe, in January; one specimen.

Batodes ilyodes n. sp.

ιλυωδης, muddy.

♂, 15-18 mm. Head fuscous. Palpi 1 and a fourth; fuscous. Antennae brownish-ochreous annulated with dark fuscous; ciliations in male minute. Thorax brownish-ochreous. Abdomen fuscous; tuft brownish-ochreous. Legs fuscous; posterior pair brownish-ochreous. Forewings dilated posteriorly, costa moderately arched, apex sharply pointed, termen slightly rounded, slightly oblique; brownish-ochreous; a large dark fuscous patch filling posterior two-fifths of wing except a narrow terminal strip with irregular anterior margin; cilia brownish-ochreous. Hindwings greyish-ochreous or pale fuscous with a few darker strigulae; cilia concolorous.

New South Wales: Murrurundi, in September and October; two specimens received from Dr. B. L. Middleton.

Batodes argillina n. sp.

argillinus, clay-coloured.

♂, 20 mm. Head and thorax brown. Palpi 1 and a fourth; brown. Antennae pale brownish annulated with dark fuscous; ciliations in male minute. Abdomen grey; tuft whitish-ochreous. Legs brown with whitish-ochreous tarsal rings; posterior pair whitish-ochreous. Forewings dilated posteriorly, costa gently arched, apex rectangular, termen not oblique; brown; a triangular mark on costa before apex, partly edged with fuscous; cilia brown. Hindwings whitish-ochreous, sparsely strigulated and reticulated with grey; cilia grey.

South Australia: Adelaide, in September; one specimen received from Mr. F. M. Angel.

Lamyrodes euchroma n. sp.

ευχρωμος, well coloured.

♂ 12 mm. Head fuscous; face grey. Palpi 2; grey. Antennae grey, annulated with fuscous; ciliations in male 1. Thorax and abdomen dark fuscous. Legs whitish. Forewings suboblong, dilated posteriorly, costa nearly straight, apex rounded, termen nearly straight, slightly oblique; male without costal fold; dark fuscous; cilia orange, on tornus fuscous. Hindwings orange; apex, terminal edge, and cilia fuscous.

New South Wales: Cudgen Hds., near Tweed Hds., in November (W. B. Barnard); one specimen.

Lamyrodes pellochroa n. sp.

πελλοχροος, grey.

♂, 14 mm. Head and thorax grey. Palpi 2; grey. Antennae grey; ciliations in male 1 and a half. Abdomen grey. Legs grey with whitish rings; posterior pair whitish. Forewings narrow, costa gently arched, apex round-pointed, termen obliquely rounded; in male without costal fold; grey with numerous fuscous dots and strigulae; a costal series of strigulae at regular intervals; a fine sinuate line from four-fifths costa to termen below middle; a shorter similar line between this and apex; cilia grey. Hindwings and cilia pale grey.

Queensland: Maryland, near Stanthorpe, in February (W. B. Barnard); two specimens. Type in Queensland Museum.

Gen. Coeloptera nov.

κοιλοπτερος, with hollowed wings.

Head rough-scaled. Tongue present. Palpi long, porrect, much thickened above and beneath; apex of terminal joint thickened with long scales. Thorax without crest. Forewings with costa strongly arched to near middle, thence

hollowed, marginal scales at junction large, apex rectangular, termen slightly sinuate, not oblique; 7 and 8 stalked, 7 to termen. Hindwings with 3 and 4 connate, 4 closely approximated to 5 at base, 6 and 7 stalked. A derivative of *Capua* with peculiarly shaped forewings.

Coeloptera castanina n. sp.

καστανινος, chestnut-brown.

♀, 16-18 mm. Head and thorax reddish-brown. Palpi 10; reddish-brown. Antennae pale grey. Abdomen fuscous. Legs ochreous-whitish. Forewings grey more or less suffused with reddish-brown; sometimes with a few slender transverse grey striae; no definite markings; sometimes several pale costal dots towards apex; cilia fuscous with pale antemedian and terminal lines. Hindwings and cilia grey.

Queensland: Bunya Mountains, in February. New South Wales: Mount Wilson, in March. Three specimens.

Capua rhynchota n. sp.

ῥυνχωτος, beaked.

♂, 14-16 mm. Head and thorax fuscous. Palpi 6; fuscous-brown, upper edge fuscous. Antennae grey; ciliations in male 1. Antennae grey. Abdomen grey. Legs ochreous-whitish; anterior pair grey. Forewings with costa strongly arched to two-fifths, thence straight, apex rectangular, termen slightly rounded, slightly oblique; in male with broad costal fold to two-fifths; brownish-fuscous; three whitish-ochreous costal dots in apical third; there are also dots in disc, very variable in development, among them a white dot just before tornus; cilia fuscous-brown. Hindwing pale grey with darker strigulae; cilia pale grey.

Queensland: Bunya Mountains, in October and April (W. B. Barnard); four specimens. Type in Queensland Museum.

Capua myopolia n. sp.

μυοπολιος, mouse-grey.

♂, 21 mm. Head whitish-ochreous; face fuscous. Palpi 1 and a fourth; fuscous. Antennae grey; ciliations in male one-half. Thorax fuscous. Abdomen with basal half grey; beyond this whitish-ochreous. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings with costa rather strongly arched, apex rounded, termen rounded, slightly oblique; male without costal fold; whitish-ochreous partly suffused with grey; an irregular rather broad fuscous stripe from mid-base to two-thirds costa, and thence to apex; a whitish-ochreous dot in disc at two-fifths, thinly edged with brown and fuscous; a narrow whitish streak on middle third of dorsum; a slender undulating fuscous line from beneath costa near apex to below middle of termen; cilia whitish-ochreous, apices fuscous. Hindwings and cilia pale grey. The shape of the forewings resembles *C. gongylia* Turn.

North Queensland: Cape York, in June (W. B. Barnard); one specimen.

Capua euthemon n. sp.

εὐθημων, well made.

♂ ♀, 12 mm. Head and thorax ochreous-brown. Palpi 2; fuscous-brown, upper edge ochreous-brown. Antennae white with blackish annulations; ciliations in male 2. Abdomen dark fuscous. Legs grey; posterior pair whitish. Forewings narrow, costa slightly arched, apex pointed, termen straight, oblique; whitish sprinkled or strigulated with ochreous; markings distinct, ochreous partly edged with fuscous; basal patch small, posterior margin sinuate, median fascia

broad, only moderately oblique, ending abruptly in a dark fuscous spot above middle of dorsum; a large triangular spot on two-thirds costa, its lower anterior angle touching median fascia; a dorsal spot before tornus; a narrow terminal fascia; cilia grey-whitish, on apex and tornus fuscous. Hindwings fuscous; cilia whitish with a fuscous sub-basal line.

Western Australia, in March (W. B. Barnard); two specimens. Type in Queensland Museum.

Capua multistriata n. sp.

multistriatus, with many striae.

♀, 15 mm. Head ochreous-grey. Palpi 2 and a half; ochreous-grey. Antennae ochreous-grey with fuscous annulations. Thorax fuscous-brown. Abdomen fuscous. Legs ochreous-whitish. Forewings narrow, costa gently arched, apex pointed, termen nearly straight, oblique; ochreous-whitish mostly suffused with reddish-ochreous; numerous dark fuscous costal dots, from which arise fine fuscous lines or striae running to dorsum, some interrupted, slightly outwardly oblique, those nearest termen bent inwards in middle; cilia ochreous-whitish. Hindwings and cilia whitish-grey.

Tasmania: Strahan, in January; one specimen.

Capua xuthochyta n. sp.

ξουθοχυτος, with brownish suffusion.

♀, 14 mm. Head, thorax, and abdomen fuscous. Palpi 2 and a half; grey. (Antennae missing.) Legs fuscous with whitish rings; posterior pair whitish. Forewings with costa gently arched, apex rounded, termen obliquely rounded; grey with fuscous strigulae, and with orange-brown suffusion and irroration; short costal and longer dorsal strigulae; a fuscous spot in middle of disc, preceded and followed by orange-brown suffusion; four oblique triangles on apical half of costa; terminal area with orange-brown irroration and minute fuscous dots; cilia grey. Hindwings and cilia grey.

Queensland: Brisbane, in January; one specimen.

Capua tapinopis n. sp.

ταπεινωπις, humble.

♂, 10 mm. Head and thorax whitish-ochreous. Palpi 1; whitish-ochreous. Antennae pale grey; ciliations in male one-half. Abdomen grey; tuft whitish. Legs whitish; anterior pair grey. Forewings narrow, costa arched near base, thence straight, apex rounded-rectangular, termen obliquely rounded; in male with a narrow costal fold to two-fifths; whitish-ochreous; a fuscous costal spot near base; a brownish transverse fascia from one-third dorsum reaching two-thirds across disc, followed by some ochreous costal suffusion; cilia whitish-ochreous. Hindwings grey; cilia whitish.

North Queensland: Malanda, Atherton Tableland, in August; one specimen.

Capua arrosta n. sp.

ἀρρωστος, weak.

♂ ♀, 11-12 mm. Head and thorax dark fuscous. Palpi 2; dark fuscous. Antennae fuscous; ciliations in male minute. Abdomen dark fuscous; tuft grey-whitish. Legs fuscous; posterior pair whitish. Forewings narrow, costa slightly arched, apex rounded, termen obliquely rounded; in male without costal fold; grey-whitish with a few slender transverse fuscous striae; markings dark fuscous; basal patch usually well defined, its posterior edge straight from one-fourth costa to one-third dorsum; median fascia variably developed, from costa before middle towards, but rarely reaching, dorsum before tornus, posterior edge usually

excavated in middle; costal triangle imperfectly developed; a fine terminal line; cilia whitish with fuscous bars. Hindwings and cilia grey.

Western Australia: Denmark, in March and April (W. B. Barnard); eight specimens. Type in Queensland Museum.

Capua belophora n. sp.

βελοφορος, carrying darts (palpi).

♂, 14 mm. Head and thorax pale ochreous-grey. Palpi 5; grey. Antennae pale ochreous-grey with fuscous annulations; in male with tufts of long cilia (3). Abdomen grey-whitish. Legs grey-whitish; anterior pair grey. Forewings with costa strongly arched, apex rectangular, termen slightly sinuate, slightly oblique; in male without costal fold; whitish tinged with ochreous and speckled throughout with fuscous or grey; darker on costal and terminal margins; cilia grey. Hindwings whitish, faintly speckled with grey.

Western Australia: Albany and Margaret River, in November; two specimens.

Capua notopasta n. sp.

νωτοπαστος, with speckled dorsum.

♂ ♀, 15-16 mm. Head and thorax ochreous-whitish. Palpi 2 and a half; ochreous-whitish, external surface sometimes grey. Antennae grey; ciliations in male minute. Abdomen grey. Legs grey; posterior pair ochreous-whitish. Forewings rather narrow, costa gently arched, apex pointed, termen almost straight, oblique; in male without costal fold; ochreous-whitish with a few fuscous dots, most numerous on costal edge; sometimes an oblique fuscous mark in mid-disc; usually a narrow triangular costal patch from middle to four-fifths; several black dots on posterior third of dorsal margin; sometimes a few minute black dots on termen; cilia grey, apices usually whitish.

South Australia: Mount Lofty, in October. Western Australia: Yanchep, in September. Three specimens.

Capua scaphosema n. sp.

σκαφοσημος, with boat-shaped marking.

♀, 14 mm. Head and thorax grey. Palpi 2; grey. Antennae grey. Abdomen grey. Legs fuscous with whitish tarsal rings; posterior pair whitish. Forewings narrow, costa slightly arched, apex round-pointed, termen obliquely rounded; ochreous-whitish; basal patch ill-defined, grey with some fuscous dots, posterior edge convex; a boat-shaped patch extending on costa from two-fifths to near apex, broader anteriorly, where it reaches midde of disc, dark fuscous mixed with ferruginous, intersected by an ochreous-whitish oblique bar with dentate margins; cilia ochreous-whitish. Hindwings and cilia grey.

New South Wales: Mount Tomah, near Mount Wilson, in March; one specimen.

Capua erythrosema n. sp.

ἐρυθροσημος, with reddish marking.

♀, 12-13 mm. Head and thorax ochreous-whitish. Palpi 3; whitish, sometimes grey on outer surface. Antennae grey. Abdomen grey. Legs ochreous-whitish. Forewings narrow, costa slightly arched, apex rectangular, termen sinuate, not oblique; white, sprinkled with pale grey; a grey patch on dorsum from one-fourth to three-fourths, anteriorly reaching to above middle of disc, but this patch is not always developed; sometimes a reddish subdorsal suffusion before middle; a well-defined reddish apical patch, its margin curved from midcosta to midtermen; in this are two pairs of white dots on costa beyond three-fourths; cilia grey. Hindwings grey; cilia whitish.

Western Australia: Albany, in February; Bunbury, in October; two specimens.

Capua adynata n. sp.

ἀδυνατος, feeble.

♀, 13 mm. Head and thorax ochreous-grey. Palpi 2; ochreous-grey. Antennae grey. (Abdomen missing.) Legs grey; posterior pair whitish. Forewings rather narrow, costa gently arched, apex pointed, termen straight, oblique; whitish sprinkled and strigulated with ferruginous; some fuscous discal dots; markings ferruginous-fuscous; median fascia rather narrow, from costa before middle, terminating abruptly in mid-disc; a triangular spot on three-fourths costa; cilia whitish. Hindwings and cilia grey-whitish.

Western Australia: Denmark, in April (W. B. Barnard); one specimen.

Capua glycypolia n. sp.

γλυκυπολιυς, sweetly grey.

♂, 16 mm. Head, thorax, and abdomen grey. Palpi 4; grey, upper edge and inner surface whitish. (Antennae missing.) Legs grey; posterior pair white. Forewings gently arched, apex pointed, slightly produced, termen sinuate, slightly oblique; in male without costal fold; grey; markings fuscous sprinkled with darker fuscous; several minute dark fuscous costal dots before median fascia; basal patch represented by a very fine line from one-fourth costa to one-fifth dorsum; some ill-defined fuscous suffusion towards base of dorsum; median fascia narrow, from costa before middle towards but not reaching dorsum before tornus; three or four minute blackish strigulae edged with whitish on costa beyond fascia; a slender blackish terminal line; cilia whitish, on apex and tornus grey. Hindwings with 3 and 4 stalked; pale grey; cilia pale grey.

Western Australia: Margaret River, in November; one specimen.

Capua acritodes n. sp.

ἀκριτωδης, disorderly.

♂, 11-13 mm. Head and thorax fuscous or grey. Palpi 1 and a half; fuscous. Antennae fuscous or grey; ciliations in male one-half. Abdomen fuscous; tuft whitish. Legs whitish; anterior pair fuscous with whitish rings. Forewings narrow, costa gently arched, apex obtuse, termen very obliquely rounded; in male without costal fold; grey-whitish with fuscous strigulae; markings fuscous; basal patch straight-edged at one-fourth; median fascia from costa before middle, at first rather narrow, broadening in disc to extend from mid-termen to tornus; a costal triangle before apex; a terminal line or series of dots; cilia whitish mixed with fuscous. Hindwings and cilia grey.

Western Australia: Denmark, in March (W. B. Barnard); seven specimens. Type in Queensland Museum.

Capua ischnomorpha n. sp.

ισχνομορφος, narrow.

♀, 16-17 mm. Head and thorax fuscous. Palpi 3; fuscous. Antennae fuscous. Abdomen grey. Legs fuscous; posterior pair whitish. Forewings narrow, costa slightly arched, apex pointed, termen very obliquely rounded; grey; markings fuscous, variable; basal patch more or less developed; an oblique bar from midcosta half across disc and a triangular costal patch usually developed; sometimes a broad fuscous dorsal streak from base to apex, sometimes a slender terminal line; cilia grey, sometimes partly fuscous. Hindwings and cilia grey-whitish.

South Australia: Adelaide (Glenelg), in May; three specimens received from Mr. J. O. Wilson.

Capua dura n. sp.

durus, stern.

♂ ♀, 16-18 mm. Head and thorax fuscous. Palpi 3; fuscous, inner surface and upper edge white. Antennae fuscous; ciliations in male 1. Abdomen grey or fuscous; tuft whitish. Legs fuscous; posterior pair fuscous. Forewings broad in male, less so in female, costa strongly arched in male, gently in female, apex rectangular, termen scarcely rounded, scarcely oblique; costal fold in male reaching two-fifths; whitish with dense fuscous-brown irroration; markings fuscous, in male expanded to fill most of disc; basal patch in female moderate, its outer edge angled above middle, in male larger and confluent with median fascia; median fascia in male very broad, expanded on costa, excavated posteriorly, in female scarcely indicated; cilia fuscous. Hindwings grey-whitish coarsely strigulated with grey; cilia white with sub-basal and subapical fuscous lines.

Western Australia: Perth and Yanchep, in September; three specimens.

Capua symphonica n. sp.

συμφωνικος, neat.

♀, 16 mm. Head dark fuscous. Palpi 1 and a half; dark fuscous. Antennae grey. Thorax dark fuscous with a whitish posterior spot. Abdomen fuscous. Legs fuscous; posterior pair whitish. Forewings with costa gently arched, apex obtusely pointed, termen almost straight, oblique; pale grey with markings and strigulae blackish partly edged with ochreous-whitish; basal patch indicated by strigulae and edged by an outwardly curved line from one-fourth costa to one-third dorsum; several costal strigulae, one larger and wedge-shaped at three-fourths; an erect quadrangular mark on two-thirds dorsum reaching middle of disc; an erect strigula from tornus; cilia fuscous, towards apex and tornus pale grey. Hindwings and cilia fuscous.

Queensland: Carnarvon Range, in January (W. B. Barnard); one specimen.

Capua phaeosema n. sp.

φαιοσημος, dusky-marked.

♂, 18 mm. Head, thorax, and abdomen fuscous. Palpi 4; fuscous, lower edge white. Antennae grey; ciliations in male 2. Legs fuscous with whitish tarsal rings; posterior pair except femora whitish. Forewings with costa gently arched, apex rectangular, termen slightly rounded, scarcely oblique; white sparsely sprinkled and dorsum strigulated with fuscous; markings fuscous, and except for a suffused basal patch distinctly outlined; an oblique bar from two-fifths costa towards but not reaching tornus, constricted beneath costa; a quadrangular spot before apex enclosing a white costal dot; a terminal line ending in a tornal spot; cilia grey with a sub-basal fuscous line. Hindwings and cilia grey.

South Australia: Noarlunga, near Adelaide, in September; one specimen received from Mr. F. M. Angel.

Capua pancapna n. sp.

παγκαπνος, all smoky.

♂, 17 mm. Head and thorax fuscous. Palpi 1; fuscous. Antennae fuscous; ciliations in male minute. Abdomen fuscous; tuft grey. Forewings broad, costa strongly arched to middle, thence straight, apex rectangular, termen sinuate, not oblique; in male without costal fold; grey with some dark fuscous strigulae; markings leaden-fuscous edged with dark fuscous; basal patch well defined, posterior edge concave from one-fourth costa to one-third dorsum; a narrow

fascia from costal edge of basal patch to mid-dorsum, much broader below middle; a wedge-shaped costal spot at three-fourths, its apex connected by a fine dentate dark fuscous line with dorsum before tornus; a similar parallel line from costa before apex to tornus; the space between these lines leaden-fuscous; a narrow terminal fascia from apex to near tornus; cilia fuscous, on tornus grey. Hindwings and cilia fuscous.

Queensland: Brisbane, in February; one specimen.

Capua tolmera n. sp.

τολμηρος, bold.

♂, 16 mm. Head and thorax dark fuscous. Palpi 1; fuscous. Antennae fuscous; ciliations in male minute. (Abdomen missing.) Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings dilated posteriorly, costa gently arched, apex rounded, termen slightly rounded, scarcely oblique; in male without costal fold; whitish with some grey sprinkling; boldly marked with fuscous partly edged with blackish; a basal patch with a median posterior angle; median fascia from midcosta to tornus, narrowly interrupted in middle, bifurcating shortly before dorsum; a narrow irregular fascia from three-fourths costa to midtermen; a costal dot before apex; a terminal line; cilia grey with some fuscous bars. Hindwings and cilia grey.

Queensland: Injune, in August (W. B. Barnard); one specimen.

Capua aurantiaca n. sp.

aurantiacus, orange.

♂ ♀, 15-18 mm. Head and thorax reddish-orange. Palpi 5 to 6; reddish-orange. Antennae pale grey; ciliations in male 2. Abdomen pale grey. Legs whitish; anterior pair grey. Forewings with costa moderately arched, apex pointed, termen slightly sinuate, slightly oblique; in male without costal fold; reddish-orange with scattered minute purple fuscous dots, best marked on costal edge; sometimes a few white dots on costa; cilia purple-fuscous. Hindwings grey-whitish obscurely dotted with purple-grey; cilia grey-whitish.

Western Australia: Albany, in November; Denmark, in March and April; twelve specimens.

Capua leucobela n. sp.

λευκοβελος, with white palpi.

♂, 16 mm. Head white. Palpi 2; white. Antennae grey; ciliations in male 1 and a half. Thorax ochreous-grey. Abdomen ochreous-grey; terminal half and tuft fuscous. Legs fuscous with whitish rings; posterior pair whitish. Forewings with costa slightly arched, apex round-pointed, termen obliquely rounded; in male without costal fold; ochreous-grey with fuscous irroration and markings; some basal fuscous suffusion; a discal suffusion beyond middle; a series of dark fuscous costal dots; cilia fuscous. Hindwings and cilia grey.

New South Wales: Murrurundi, in March; one specimen received from Dr. B. L. Middleton.

Adoxophyes thelcteropa n. sp.

θελτηρωπος, charming.

♂, 11-14 mm. Head pale ochreous. Palpi 1 and a fourth; pale ochreous. Antennae pale ochreous with fuscous annulations; ciliations in male one-half. Thorax pale ochreous with patagia and some irroration reddish. Abdomen pale grey; apical segments and tuft pale ochreous. Legs whitish-ochreous; posterior pair white. Forewings broadly dilated, costa strongly arched, apex rectangular, termen slightly rounded, not oblique; in male with a broad costal fold reaching

two-fifths; white sprinkled with reddish; costal fold minutely strigulated with dark fuscous; basal patch with irregular mottling and margin; a moderate oblique grey central fascia from middle of costa gradually enlarging to extend from three-fifths to tornus; a grey bar on costa from two-thirds to near apex, extended by a subterminal process to near tornus; cilia whitish. Hindwings and cilia whitish.

North Queensland: Cape York, in June, October and November (W. B. Barnard), Cairns (F. P. Dodd); eight specimens. Type in Queensland Museum.

Adoxophyes ablepta n. sp.

ἀβλεπτος, inconspicuous.

♀, 22-24 mm. Head and thorax grey. Palpi 2 and a half to 3; grey. Antennae grey. Abdomen pale ochreous-grey. Legs ochreous-whitish; anterior pair grey. Forewings dilated posteriorly, costa strongly arched, apex pointed, slightly produced, termen sinuate, not oblique; whitish-ochreous with grey markings, both minutely strigulated; no basal patch; median fascia ill-defined or almost obsolete, from midcosta, where it is narrow, becoming broader towards tornus; a fairly well-defined apical triangle extending from three-fourths costa to midtermen; cilia ochreous-whitish, apices usually dark fuscous, on tornus wholly whitish. Hindwings whitish-ochreous, towards base grey; cilia grey-white.

Queensland: Toowoomba, in September and October (W. B. Barnard); four specimens. Type in Queensland Museum.

Adoxophyes amblychroa n. sp.

ἀμβλυχροος, dull-coloured.

♂, 16 mm. Head, thorax, and abdomen grey. Palpi 2; grey. Antennae grey; ciliations in male one-half. Legs ochreous-whitish. Forewings broad, costa strongly arched to middle, thence almost straight, apex rectangular, termen straight, not oblique; costal fold in male reaching one-fourth; ochreous-whitish with obscure pale fuscous strigulae; markings pale fuscous; basal patch scarcely indicated; median fascia indicated by a triangular spot on costa before middle, and a suffused dorsal patch before tornus; a well-defined triangular apical patch, its anterior edge from two-thirds costa to about midtermen, nearly straight; posterior edge submarginal; cilia ochreous-whitish. Hindwings and cilia pale grey.

Queensland: Toowoomba, in September and October (W. B. Barnard); three specimens. Type in Queensland Museum.

Homona similana (Wlk.)

Meyr., Proc. Linn. Soc. N.S.W., 1881, 466.

H. stenophracta Turn., Trans. Roy. Soc. S. Aust., 1925, 211, is a synonym.

Homona ecprepes n. sp.

ἐκπρεπης, distinguished.

♂, 26 mm. Head and thorax dark reddish-brown. Palpi 1; reddish-brown. Antennae grey; ciliations in male one-half. Abdomen reddish-ochreous. Legs ochreous; posterior pair whitish. Forewings with costa sinuate, apex pointed, slightly produced, termen sinuate, not oblique; pale purplish-grey; costal edge reddish; a dark reddish-brown basal patch, towards termen reddish-grey, commencing on one-fourth costa, angled beneath costa, thence inwardly curved to one-fourth dorsum; two short, acute reddish-brown streaks from and from above angle of basal patch, the former longer; a purplish-grey costal line from middle to near apex, leaving costal edge reddish; a narrow ochreous wedge, broadest above, before termen, its apex reaching terminal edge; cilia purplish-fuscous,

towards tornus whitish. Hindwings broad, termen strongly rounded; reddish-ochreous, near dorsum whitish-ochreous; cilia whitish, on apex purplish-grey.

North Queensland: Cape York, in October (W. B. Barnard); one specimen.

Homona notoplaga n. sp.

νωτοπλαγος, with dorsal patch.

♀, 28 mm. Head grey. Palpi 1; brown. Antennae pale grey. Abdomen whitish; base of dorsum grey. Legs ochreous-whitish. Forewings dilated posteriorly, costa sinuate, apex pointed, somewhat produced, termen sinuate, not oblique; pale brownish; a series of minute dark fuscous costal dots; a large triangular dark fuscous dorsal patch from one-fifth to tornus; its apex reaching nearly half across disc; cilia fuscous, on lower third of termen ochreous-whitish. Hindwings with termen sinuate; whitish-ochreous, dorsal area with suffused grey strigulae; cilia whitish.

Queensland: Macpherson Range, in November (W. B. Barnard); one specimen.

Tortrix sobrina n. sp.

sobrinus, akin.

♂, 18 mm. Head grey; face whitish. Palpi 2; grey. Antennae pale grey; ciliations in male 1. Thorax fuscous. Abdomen fuscous; tuft grey-whitish. Legs whitish; anterior pair fuscous with whitish rings. Forewings strongly arched to middle, apex rectangular, termen nearly straight, in male with a rather broad costal fold extending to one-third; grey-whitish with fuscous dots and strigulae; markings fuscous with darker dots; basal patch undefined; median fascia narrow, from before middle, expanding in disc so as to reach from three-fifths dorsum almost to tornus; a narrow costal triangle from three-fifths to four-fifths; a small suffusion before termen above middle; cilia grey with a basal series of darker dots. Hindwings with darker strigulae towards margins; cilia grey.

Queensland: Brisbane, in October; one specimen.

Tortrix phaeoscia n. sp.

φαιοσκιος, darkly shaded.

♂, 24 mm. Head whitish-brown. Palpi 1 and a half; fuscous. Antennae whitish; ciliations in male one-half. Abdomen fuscous; sides and tuft whitish. Legs whitish. Forewings with costa strongly arched to middle, thence straight, apex rectangular, termen slightly rounded, slightly oblique; in male with a costal fold extending to middle; whitish-brown; markings fuscous; basal patch scarcely indicated; median fascia from one-third costa, soon confluent with a large triangular blotch, which extends to apex and tornus, indented in middle posteriorly; an irregular subterminal spot opposite indentation; some minute dots on dorsum; an interrupted line near terminal edge; cilia whitish-brown. Hindwings pale fuscous; cilia whitish.

Queensland: Bunya Mountains, in October (W. B. Barnard); one specimen.

Tortrix cerussata Meyr.

Proc. Linn. Soc. N.S.W., 1910, 234.

T. spodota Meyr., *ibid.*, 234, is, I think, a synonym.

Tortrix phoenicoplaca n. sp.

φοινικοπλακος, with dark reddish blotch.

♀, 16 mm. Head whitish-grey. Palpi 2 and a half; whitish-grey, lower edge whitish. Thorax dark reddish; tegulae whitish-grey. Abdomen grey.

Forewings with costa slightly arched, apex rectangular, termen straight, not oblique; whitish-grey; numerous short oblique dark reddish costal strigulae; a large distinctly defined dark reddish dorsal blotch extending two-thirds across disc, its edge subcostal to two-thirds, thence outwardly curved almost to tornus; cilia whitish-grey, towards apex with blackish bases. Hindwings and cilia grey.

Queensland: Cunnamulla, in February; one specimen received from Mr. N. Geary.

Tortrix eusticha n. sp.

εὐστιχος, well streaked.

♂ ♀, 16-22 mm. Head and thorax grey. Palpi 2 and a half; grey. Antennae grey; ciliations in male one-half. Abdomen grey; tuft whitish. Legs grey; posterior pair whitish. Forewings with costa strongly arched to middle, thence straight, apex obtusely pointed, termen obliquely rounded; in male with a narrow costal fold reaching to one-third; white; all interneural spaces streaked throughout with fuscous; cilia white. Hindwings grey; cilia white.

Western Australia: Albany, in February and March; Perth; four specimens. Type in Queensland Museum.

Tortrix leucocephala n. sp.

λευκοκεφαλος, with white head.

♂, 17 mm. Head white. Palpi 2 and a half; pale grey. Antennae grey; ciliations in male 1. Thorax fuscous. Abdomen grey; tuft white. Legs grey; posterior pair whitish. Forewings rather narrow, costa slightly arched, apex rectangular, termen straight, slightly oblique; in male without costal fold; light fuscous; a broad whitish costal streak narrowing to a point at base and apex, with some fuscous scales on dorsal edge; cilia fuscous. Hindwings broad; grey-whitish faintly strigulated with grey; cilia grey, on tornus whitish.

Tasmania: Waratah, in January; one specimen.

Tortrix didymosticha n. sp.

διδυμοστιχος, twin-lined.

♀, 17 mm. Head and thorax whitish sprinkled with dark fuscous. Palpi 3 and a half; grey. Antennae dark fuscous. Abdomen fuscous. Legs dark fuscous with whitish rings; posterior pair paler. Forewings rather narrow, dilated posteriorly, apex rounded, termen oblique; dark fuscous with two narrow oblique white fasciae, first from one-third costa to before mid-dorsum, second from two-thirds costa to before tornus, each bisected by a narrow interrupted fuscous line, some white irroration in basal area; two white costal dots before apex; a subterminal series of blackish dots; cilia white with apices and a sub-basal line fuscous. Hindwings grey; cilia grey-whitish with a sub-basal grey line.

Western Australia: Albany, in March (W. B. Barnard); one specimen.

Tortrix trimochla n. sp.

τριμοχλος, thrice-barred.

♂, 14-16 mm. Head and thorax fuscous. Palpi 2 and a half; fuscous, lower edge towards base white. Antennae fuscous; ciliations in male minute. Abdomen grey. Legs white with dark fuscous rings; posterior pair mostly white. Forewings with costa slightly arched, apex rounded, termen straight, not oblique; in male without costal fold; white with three fasciae fuscous-brown edged with dark fuscous dots; first fascia sub-basal; second fascia from costa before middle to three-fifths dorsum; third from three-fourths costa to tornus; dark fuscous dots on costa between fasciae; a dark fuscous transverse line just before termen; cilia pale grey with some dark fuscous basal dots. Hindwings and cilia grey.

North Queensland: Cape York, in April (W. B. Barnard); four specimens. Type in Queensland Museum.

Tortrix irenica n. sp.

εἰρηνικος, peaceful.

♂ ♀, 19-22 mm. Head and thorax pale grey or whitish; face white. Palpi 2 and a half; pale grey. Antennae grey; ciliations in male one-half. Abdomen grey-whitish; tuft whitish. Legs whitish; anterior pair grey. Forewings rather narrow, costa arched to one-third, thence straight, apex rectangular, termen slightly rounded, slightly oblique; white more or less sprinkled with ochreous and grey; costal edge near base grey; markings grey more or less mixed with ochreous; a short oblique bar from two-fifths costa soon bent and continued beneath costa nearly to termen; a suffused spot or short oblique bar from two-thirds dorsum not quite reaching subcostal line; a grey terminal suffusion; cilia white. Hindwings pale grey; cilia white.

Western Australia: Albany and Busselton, in February (W. B. Barnard); six specimens. Type in Queensland Museum.

Tortrix pulla n. sp.

pullus, gloomy.

♂, 18 mm. Head and thorax fuscous. Palpi 3; fuscous, lower edge whitish. Antennae grey; ciliations in male 1 and a half. Abdomen grey; tuft grey-whitish. Legs fuscous with whitish rings; posterior pair whitish. Forewings with costa strongly arched, apex pointed, termen obliquely rounded; costal fold in male rather broad, extending nearly to middle; grey thickly sprinkled with fuscous; markings dark fuscous; a small triangular spot on costa near base; central fascia narrow from two-fifths costa, interrupted in disc, rather broader but suffused on dorsum, where it extends from three-fifths to tornus; a small suffusion before middle of termen; a terminal line; cilia grey-whitish, on tornus fuscous. Hindwings pale grey with darker grey mottling; cilia grey-whitish.

Western Australia: Yanchep, in September; one specimen.

Tortrix campylosema n. sp.

καμπυλοσηος, with bent marking.

♂, 19 mm. Head grey-whitish. Palpi 2; fuscous. Antennae fuscous; ciliations in male 1. Thorax fuscous; tegulae grey-whitish. Abdomen grey-whitish. Legs dark fuscous; posterior pair whitish. Forewings with costa gently arched, apex pointed, termen straight, oblique; in male with a narrow costal fold to one-third; whitish mostly heavily sprinkled with fuscous; markings fuscous; an oblique bar from one-sixth costa to fold; a second bar from one-third costa to middle of disc, giving off a broad subcostal streak to apex; a suffused spot above tornus; four sharply defined dark fuscous dots on posterior half of costa; fine short streaks on veins running to termen; cilia whitish with a series of basal dots. Hindwings grey; cilia white with a sub-basal grey line.

Tasmania: Flinders Island, in November; one specimen.

Tortrix ammotypa n. sp.

ἀμμοτυπος, with sand-coloured markings.

♂, 19 mm. Head and thorax pale grey. Palpi 2; pale grey, lower edge white. Antennae whitish; ciliations in male 1. Abdomen white. Legs white; anterior pair grey. Forewings gently arched, apex rounded, termen obliquely rounded; in male without costal fold; grey-whitish; markings ochreous-brown, somewhat suffused; a broad interrupted costal streak from base to apex; a short

subdorsal streak; a discal suffusion at one-fourth; an upwardly curved streak from middle of disc to termen beneath tornus; a dorsal spot at three-fourths; some dark fuscous scales on termen; cilia white. Hindwings white, tinged with grey towards apex; cilia white.

South Australia: Adelaide (Glenelg), in April; one specimen received from Mr. J. D. Wilson

TORTRIX EURYSTROPHA Turn.

Trans. Roy. Soc. S. Aust., 1926, 135.

T. hemiphoena Turn., Proc. Roy. Soc. Tasm., 1926, 126, and *T. loxotoma* Turn., Proc. Roy. Soc. Tasm., 1926, 127, are synonyms.

Queensland: Brisbane, Macpherson Range, Toowoomba, Bunya Mountains. New South Wales: Murrurundi, Canberra. Tasmania: Waratah, Zeehan, Strahan, Russell Falls, Mount Wellington. Western Australia: Yanchep.

Tortrix sordida n. sp.

sordidus, dingy.

♂, 20 mm. Head and thorax fuscous. Palpi 2; fuscous. Antennae fuscous; ciliations in male minute. Abdomen grey. Legs mostly fuscous; posterior pair whitish. Forewings dilated posteriorly, costa slightly arched, apex rounded, termen obliquely rounded; in male with a moderately broad costal fold extending to one-third; whitish densely sprinkled with fuscous and brownish; markings pale fuscous surrounded by some brownish suffusion; a dot on base of costa; a dot on end of cell and another beneath cell; a subterminal series of minute dots; cilia whitish. Hindwings and cilia grey.

Queensland: Macpherson Range, in February (W. B. Barnard); one specimen.

Tortrix cnecochyta n. sp.

κνηκοχυτος, suffused with yellowish.

♂, 19 mm. Head pale greyish-ochreous. Palpi 2 and a half; fuscous; inner surface whitish. Antennae grey; ciliations in male 1. Thorax fuscous. Abdomen grey; tuft whitish. Forewings narrow, costa gently arched, apex pointed, termen sinuate, oblique; in male without costal fold; whitish thickly sprinkled with grey and ochreous; basal patch large, mostly ochreous; costa with dark fuscous strigulae and two dark fuscous spots at two-fifths and four-fifths; cilia whitish-ochreous. Hindwings and cilia grey.

New South Wales: Scone, in July, from larva feeding on *Bassia quinquecuspis;* one specimen received from Mr. H. Nicholas.

Tortrix lypra n. sp.

λυπρος, poor.

♂, 18 mm. Head and thorax fuscous. Palpi 3; fuscous. Antennae grey; ciliations in male 1. Abdomen pale fuscous; tuft whitish. Legs whitish; anterior pair fuscous with whitish rings. Forewings strongly arched to middle, thence straight, apex rectangular, termen obliquely rounded; in male with costal fold almost reaching middle; whitish more or less suffused with grey; markings fuscous; basal patch with outer edge angled in middle; median fascia narrow, from two-fifths costa to tornus, sometimes obsolete towards dorsum, or interrupted beneath costa; a small costal triangle at two-thirds; an erect mark from tornus to about halfway across disc; some subterminal suffusion; cilia whitish sometimes mixed with fuscous. Hindwings and cilia pale grey.

Western Australia: Albany, Nornalup, and Margaret River, in October and November; Yanchep in September; five specimens.

Tortrix ischnosema n. sp.

ἰσχνοσημος, with narrow marking.

♂, 19 mm. Head and thorax greyish-ochreous. Palpi 2; greyish-ochreous. Antennae grey; ciliations in male one-half. Abdomen grey; tuft whitish. Legs fuscous; posterior pair grey. Forewings with costa gently arched, apex round-pointed, termen obliquely rounded; in male with costal fold reaching almost to middle; grey-whitish with some sprinkling of ochreous and fuscous; markings fuscous; basal patch ill-defined, mostly ochreous; dorsal area suffused with grey; central fascia very narrow; from two-fifths costa towards but not reaching tornus; a small well-defined semilunar mark on costa at three-fourths; cilia grey-whitish. Hindwings and cilia grey.

Queensland: Toowoomba, in September (W. B. Barnard); one specimen.

Tortrix euphara n. sp.

εὐφαρος, well attired.

♀, 22 mm. Head and thorax fuscous. Palpi 2 and a half; fuscous, lower edge whitish. Antennae dark fuscous with white annulations. Abdomen brown; tuft whitish. Legs ochreous-whitish; anterior pair fuscous. Forewings with costa gently arched, apex pointed, termen almost straight, oblique; whitish-ochreous with fuscous markings; basal patch imperfectly developed; four costal dots in basal third; median fascia narrow, from two-fifths costa to two-thirds dorsum, interrupted in middle; a curved line from and to costa near apex enclosing a shallow bisected area; a costal dot before apex; two confluent spots before lower part of termen, to which they are connected by fine lines on veins; a broad terminal line; cilia whitish-ochreous, on tornus grey. Hindwings brown; cilia whitish-ochreous.

Queensland: Milmerran, in September; one specimen received from Mr. J. Macqueen.

Tortrix phaeoneura n. sp.

φαιονευρος, dark-lined.

♂, 18 mm. Head and thorax pale grey. Palpi 2 and a half; pale grey. Antennae pale grey; ciliations in male one-half. Abdomen grey-whitish; tuft ochreous-whitish. Legs grey; posterior pair ochreous-whitish. Forewings with costa moderately arched, apex obtuse, termen slightly rounded, oblique; male without costal fold; whitish; veins heavily sprinkled with fuscous; cilia whitish. Hindwings and cilia grey-whitish.

Western Australia: Albany, in February (W. B. Barnard); two specimens. Type in Queensland Museum.

Tortrix atacta n. sp.

ἀτακτος, confused.

♂ ♀, 20-22 mm. Head whitish-ochreous. Palpi 5; fuscous. Antennae fuscous; ciliations in male 3. Abdomen grey. Legs ochreous-whitish with fuscous rings; posterior pair wholly ochreous-whitish. Forewings with costa slightly arched, apex round-pointed, termen nearly straight, oblique; in male without costal fold; fuscous; basal and dorsal areas variably mixed with white; some white costal strigulae; short oblique series of white dots running to apex, sometimes confluent; terminal area more or less white; cilia fuscous. Hindwings and cilia grey.

New South Wales: Tooloom, in April; Ebor, in March; eight specimens.

Tortrix plagiomochla n. sp.

πλαγιομοχλος, with oblique bar.

♂, 15 mm. Head and thorax white. Palpi 2 and a half; grey. Antennae white with dark fuscous annulations; ciliations in male 1 and a half. (Abdomen missing.) Legs white; anterior pair grey with white rings. Forewings with costa scarcely arched, apex pointed, termen slightly rounded, oblique; in male without costal fold; white with some grey strigulae; markings dark fuscous; basal patch moderately angled outwards in middle, not reaching costa; median fascia represented by a broad oblique bar from costa before middle to beyond middle of disc; an elongate costal patch from three-fifths costa almost to apex; a short erect streak from dorsum before tornus; a terminal line not reaching apex and tornus; cilia grey, and apex white. Hindwings and cilia grey-whitish.

Western Australia: Denmark, in April (W. B. Barnard); one specimen.

Tortrix plagiograpta n. sp.

πλαγιογραπτος, obliquely marked.

♀, 14 mm. Head, thorax, and abdomen pale grey. Palpi 4; pale grey. Antennae pale grey. Legs grey-whitish; posterior pair whitish. Forewings narrow, costa gently arched, apex sharply pointed, termen sinuate, oblique; whitish with obscure fuscous strigulae mostly on margins; a rather broad oblique bisinuate fuscous line, ending obtusely, from one-third costa to middle of disc; fine fuscous lines on veins running to termen; a dark fuscous terminal line; cilia grey-whitish. Hindwings and cilia white.

Western Australia: Denmark, in November; one specimen.

Tortrix procapna n. sp.

προκαπνος, dusky in front.

♂ ♀, 20-24 mm. Head and thorax fuscous-grey. Palpi 3 to 3 and a half; fuscous-grey, lower edge white. Antennae grey; ciliations in male 1. Abdomen grey-whitish. Legs fuscous; posterior pair grey-whitish. Forewings narrow, costa strongly arched to middle, thence straight, apex rounded-rectangular, termen obliquely rounded; in male with a very narrow costal fold to one-third; whitish-ochreous with sparsely scattered black scales; cilia ochreous-whitish. Hindwings and cilia grey-whitish.

Western Australia: Denmark, in March (W. B. Barnard); two specimens. Type in Queensland Museum.

Arotrophora polypasta n. sp.

πολυπαστος, much sprinkled.

♀, 24 mm. Head and thorax dark fuscous. Palpi 3 and a half; inner surface and a minute terminal dot on third joint whitish. Antennae dark fuscous. Abdomen fuscous. Legs dark fuscous with whitish rings; posterior pair mostly whitish. Forewings with costa strongly arched, apex obtusely pointed, termen straight, slightly oblique; whitish partly suffused with dark fuscous; costa and dorsum strigulated with dark fuscous; a moderate basal patch strongly angled in middle; following this a whitish costal triangle to two-fifths; dorsal edge whitish with dark fuscous strigulae; a broad whitish fascia from apex to tornus, strongly angled inwards; a triangular dark fuscous patch between this and termen; cilia fuscous sprinkled with whitish. Hindwings and cilia grey.

Queensland: Bunya Mountains, in February (W. B. Barnard); one specimen.

Arotrophora amorpha n. sp.

ἀμορφος, without pattern.

♂, 18-24 mm. Head and thorax dark grey. Palpi 5; dark grey. Antennae dark grey; ciliations in male minute. Abdomen grey. Legs fuscous; posterior pair whitish. Forewings with costa strongly arched, apex obtusely pointed, termen slightly rounded, slightly oblique; dark grey sprinkled with fuscous, a more or less distinct fuscous line from three-fifths costa to two-thirds dorsum; some subterminal fuscous striae; cilia fuscous. Hindwings pale grey with darker grey strigulae; cilia pale grey.

New South Wales: Ebor, in December; three specimens.

Arotrophora sphenotypa n. sp.

σφηνοτυπος, marked with a wedge.

♀, 15-18 mm. Head and thorax grey. Palpi 5; grey. Antennae grey. Abdomen grey. Legs grey; posterior pair whitish. Forewings with costa gently arched, apex sharply pointed, termen straight, strongly oblique; whitish-grey with a few fuscous dots in basal area and on dorsum; a fuscous costal triangle from one-third to apex, touching posterior extremity of cell, with some darker marginal dots; a blackish terminal line preceded by some grey suffusion; cilia grey. Hindwings and cilia grey-whitish.

Western Australia: Albany and Margaret River, in November; Perth, in September; four specimens.

Arotrophoa myophanes n. sp.

μυοφανης, mouse-like.

♂, 18 mm. Head, thorax, and abdomen grey. Palpi 3 and a half; whitish, upper edge and terminal joint grey. Antennae grey; ciliations in male minute. Legs grey; tarsi with whitish rings; posterior pair whitish. Forewings with costa strongly arched, apex rectangular, termen rounded, not oblique; grey with very fine fuscous strigulae; numerous dark fuscous costal dots, those on apical half separated by whitish-ochreous dots; two silvery-whitish transverse lines before termen, connected by very fine longitudinal fuscous lines; a whitish-ochreous terminal line, edged anteriorly by dark fuscous; cilia grey, around tornus whitish. Hindwings grey; cilia whitish.

Queensland: Mount Tamborine, in November; one specimen.

Meritastis siniodes n. sp.

σινιωδης, like a sieve.

♀, 21 mm. Head and thorax greyish-yellow. Palpi 1; ochreous-whitish. Antennae whitish-grey. Abdomen and legs whitish. Forewings dilated posteriorly, costa gently arched, apex rounded-rectangular, termen not oblique; white finely reticulated and strigulated with greyish-yellow; cilia greyish-yellow. Hindwings and cilia white.

South Australia: Ooldea, in October; one specimen.

Epichorista phaeoplaca n. sp.

φαιοπλακος, with dusky patch.

♀, 18 mm. Head and thorax grey. Palpi 2 and a half; grey, extreme apex of third joint whitish. (Abdomen missing.) Legs grey; anterior pair fuscous with whitish rings. Forewings with costa strongly arched, apex rounded, termen obliquely rounded; whitish-grey with fuscous markings; basal patch well defined, margin straight to near dorsum, where it is indented; median fascia with anterior edge fairly well defined, straight from before middle of costa to near dorsum,

posterior edge indefinite, confluent with costal triangle; some subterminal strigulae or striae; cilia whitish-grey. Hindwings and cilia grey.

North Queensland: Mackay, in May; one specimen.

Epichorista spodophanes n. sp.

σποδοφανης, grey.

♂, 18 mm. Head, thorax, and abdomen pale grey. Palpi 2 and a half; pale grey. Antennae grey; ciliations in male nearly 1. Legs grey. Forewings narrow, costa gently arched, apex pointed, termen very obliquely rounded; pale grey; a fuscous discal dot at two-thirds; cilia whitish. Hindwings and cilia whitish-grey.

Victoria: Halls Gap, in November; one specimen received from Mr. C. Borch.

Epichorista homopolia n. sp.

ὁμοπολιος, uniformly grey.

♂, 15 mm. Head and thorax fuscous. Palpi 2 and a half; fuscous. Antennae fuscous; ciliations in male minute. Abdomen grey. Legs fuscous; posterior pair whitish. Forewings narrow, posteriorly dilated, apex obtuse, termen obliquely rounded; uniform grey; cilia grey. Hindwings and cilia pale grey.

Queensland: Stanthorpe, in November; one specimen.

Epichorista loxomochla n. sp.

λοξομοχλος, with an oblique bar.

♂, 15 mm. Head and thorax pale ochreous. Palpi 2 and a half; pale ochreous. Antennae pale ochreous annulated with dark fuscous; ciliations in male minute. Abdomen grey; tuft pale ochreous. Legs ochreous-whitish; anterior pair with fuscous bars. Forewings with costa moderately arched, apex pointed, termen straight, oblique; ochreous-whitish; markings fuscous; a narrow fascia from midcosta to two-thirds dorsum, preceded by some dorsal suffusion; a broadly suffused streak from apex meeting fascia on dorsum; a series of costal strigulae beyond middle; cilia ochreous-whitish with a median fuscous line. Hindwings and cilia grey.

New South Wales: Murrurundi, in February; one specimen received from Dr. B. L. Middleton.

Epichorista eurymochla n. sp.

εὐρυμοχλος, broad-barred.

♂, 14 mm. Head ochreous-whitish. Palpi 2 and a half; ochreous-whitish. Antennae grey; ciliations in male minute. Thorax and abdomen fuscous. Forewings with costa moderately arched, apex obtuse, termen slightly rounded, slightly oblique; ochreous-whitish; markings fuscous; some costal dots; median fascia from midcosta to tornus, interrupted in disc, suffusedly broadened on dorsum; an apical spot; an inwardly curved streak from midtermen towards but not reaching costa; a fine terminal line; cilia ochreous-whitish. Hindwings and cilia grey.

Queensland: Stanthorpe, in April (W. B. Barnard); one specimen.

Cnephasia arescophanes n. sp.

ἀρεσκοφανης, pleasing.

♀, 12 mm. Head and thorax brownish. Palpi 2; brownish. Antennae pale brownish. Abdomen grey. Forewings with costa gently arched, apex subrectangular, termen straight, slightly oblique; grey with brown markings; basal patch large, posterior edge angled, grey with brown transverse lines; a narrow

fascia from midcosta to three-fifths dorsum; a series of costal strigulae; a circular subterminal spot connected by slender lines with tornus and midtermen; a dark brown apical dot; cilia grey. Hindwings and cilia pale grey.

North Queensland: Cape York, in June (W. B. Barnard); one specimen.

Cnephasia rutilescens n. sp.

rutilescens, reddish.

♀, 15-18 mm. Head whitish-ochreous. Palpi 3; pale grey. Antennae grey. Thorax pale grey. Abdomen grey. Forewings with costa very slightly arched, more strongly near apex, apex pointed, termen straight, oblique; pale grey; a rounded ferruginous-reddish apical blotch, edged by a broad whitish line from two-thirds costa to slightly above tornus; cilia whitish. Hindwings with 3 and 4 stalked; rather dark grey; cilia whitish with a grey sub-basal line.

Queensland: Chinchilla, in October; Leichardt, in January; Injune, in November; three specimens.

Cnephasia ochroplaca n. sp.

ὠχροπλακος, with pale blotch.

♀, 18 mm. Head and thorax fuscous. Palpi 2; fuscous. Antennae grey. (Abdomen missing.) Legs fuscous with whitish rings; posterior pair fuscous. Forewings with costa slightly arched, apex rounded, termen nearly straight, not oblique; fuscous; costa with dark fuscous strigulae; a large ochreous-whitish apical patch, edged anteriorly by a clear white line not reaching margins; costal edge of disc curved to near apex, well defined, dorsal edge to termen above tornus, suffused; in it two blackish streaks above tornus, an upwardly curved dark fuscous mark from midtermen, and several costal strigulae; cilia ochreous-whitish with fuscous bars. Hindwings grey with obscure darker strigulae; cilia pale grey.

Queensland: Bunya Mountains, in February (W. B. Barnard); one specimen.

Cnephasia catarrapha n. sp.

καταρραφος, patched.

♂ ♀, 16 mm. Head and thorax fuscous. Palpi 2; fuscous. Antennae whitish annulated with fuscous; ciliations in male minute. Abdomen grey. Forewings gently arched, apex obtuse, termen straight, oblique; whitish much sprinkled with fuscous; markings fuscous; basal patch with a median posterior angle, incomplete towards costa; median fascia moderate from costa to fold, there deflected to tornus; an oblong spot on three-fourths costa, sometimes confluent with median fascia; a subcostal suffused spot on termen; sometimes also confluent; cilia fuscous. Hindwings and cilia grey.

Tasmania: Wilmot, in February (W. B. Barnard); two specimens. Type in Queensland Museum.

Cnephasia pallida n. sp.

pallidus, pale.

♂, 14 mm. Head and thorax grey. Palpi 2; grey. Antennae grey; ciliations in male 1. Abdomen grey; tuft whitish. Forewings narrow, costa gently arched, apex pointed, termen straight, oblique; whitish with a few minute fuscous dots; cilia whitish. Hindwings and cilia whitish.

Western Australia: Margaret River, in November; one specimen.

Cnephasia polia n. sp.

πολιος, grey.

♂, 18 mm. Head, thorax, and abdomen grey. Palpi 2; grey. Antennae grey; ciliations in male 1. Forewings rather narrow, costa gently arched, apex

pointed, termen sinuate, not oblique; in male without costal fold; grey; a fine whitish subcostal line edged with fuscous from base to beyond middle; a broad whitish streak from apex half across disc; some whitish terminal suffusion; cilia whitish. Hindwings and cilia whitish-grey.

New South Wales: Sydney; one specimen.

Gen. **Eremas** nov.

ἐρημας, lonely.

Palpi ascending. Thorax with a strong posterior crest. Forewings with 7 and 8 separate, 7 to termen. Hindwings with 3 and 4 connate. 5 approximated, 6 and 7 connate.

Eremas leucotrigona n. sp.

λευκοτριγωνος, with whitish triangle.

♂, 11-15 mm. Head and thorax blackish. Palpi 2; blackish. Antennae fuscous; ciliations in male minute. Abdomen light fuscous; tuft ochreous-whitish. Legs fuscous with whitish rings; posterior pair whitish. Forewings with costa gently arched, apex rounded, termen obliquely rounded; blackish; a large ochreous-whitish costal triangle from two-fifths almost to apex, extending half across disc, containing some blackish dots on costal margin; cilia blackish. Hindwings and cilia grey.

North Queensland: Cape York, in October (W. B. Barnard); nine specimens. Type in Queensland Museum.

Schoenotenes craspedospila n. sp.

κρασπεδοσπιλος, with marginal spots.

♀, 20 mm. Head and thorax ochreous-whitish. Palpi 2 and a half; grey. Antennae grey. Abdomen with basal segments whitish-ochreous; terminal segments grey, with fuscous apices; tuft whitish. Legs whitish; anterior pair and middle tarsi fuscous. Forewings rather narrow, costa moderately arched, apex rounded, termen obliquely rounded; whitish with some pale ochreous suffusion; markings blackish; an oblong costal spot at two-fifths, costal edge before this with strigulae, and after with a series of dots; a few scattered dots in disc; a slight suffusion on three-fifths dorsum; an interrupted terminal line; cilia whitish with an antemedian blackish line. Hindwings and cilia pale grey.

New South Wales: Ebor, in December; Murrurundi, in November; two specimens.

Schoenotenes multilinea n. sp.

multilineus, many-lined.

♂, 12 mm. Head pale ochreous. Palpi 1; whitish. Antennae fuscous; ciliations in male minute. Thorax fuscous; tegulae pale ochreous. Abdomen fuscous. Legs whitish; anterior pair grey. Forewings dilated posteriorly, costa gently arched, apex obtusely pointed, termen obliquely rounded; pale ochreous suffused with grey, except towards base and on margins; a small basal fascia and numerous wavy transverse lines fuscous; a pale ochreous terminal line; cilia whitish with a series of blackish basal dots. Hindwings and cilia pale grey.

Queensland: Brisbane, in November; two specimens.

Scolioplecta rigida (Meyr.)

Proc. Roy. Soc. N.S.W., 1910, 275.

This species should be transferred here from *Epichorista.*

Gen. **Neurospades** nov.

νευροσπαδης, with string drawn back.

Palpi long, porrect. Thorax with a small posterior crest. Forewings with 7 and 8 separate, 7 to termen. Hindwing with 3 and 4 connate, 5 approximated, 7 from before end of cell widely separate from 6.

Characterised by the neuration of the hindwing, which differs from that of *Isotrias* figured by Meyrick in the General Insectorum (pl. iv, fig. 67) in the origin of 7 from before angle of cell, and the absence of a median vein in cell.

Neurospades anagaura n. sp.

ἀναγαυρος, plain.

♂, 19 mm. Head whitish. Palpi 3; whitish, terminal joint fuscous. Antennae grey; ciliations in male one-third. Thorax fuscous; tegulae whitish. Abdomen pale fuscous. Legs fuscous; posterior pair whitish. Forewings with costa gently arched, apex pointed, termen sinuate, slightly oblique; in male without costal fold; grey sprinkled with ochreous and blackish; costa with blackish dots separated by white; no defined basal patch; median fascia broad from middle of costa, becoming narrow as it approaches two-thirds dorsum; a straight-edged terminal fascia from three-fourths costa to tornus; a series of blackish dots from costa near apex to below middle of termen; cilia dark fuscous mixed with white. Hindwings and cilia grey.

Western Australia: Denmark, in March (W. B. Barnard); one specimen.

Summary

The present paper deals with the subfamily Phalonianae, of which there are few Australian species, and the Tortricinae, which are largely represented here. In it are described 10 new genera and 81 new species. It also contains some additions to the synonymy. The subfamily Rucosminae will form the subject of a future paper.

GERMINATION STUDIES OF AUSTRALIAN CHENOPODIACEAE WITH SPECIAL REFERENCE TO THE CONDITIONS NECESSARY FOR REGENERATION

1. ATRIPLEX VESICARIUM Heward

By Nancy T. Burbridge, B.Sc., Waite Agricultural Research Institute
(Read 10 May 1945)

Summary

Continued utilization of the arid pastoral country in Australia is likely to be impossible unless there is effective regeneration of the edible perennial shrubs, of which bladder saltbush, *Atriplex vesicarium*, is one of the most important. Natural regeneration does not take place with sufficient rapidity. Many factors are involved, but a study of the characteristics of germination is a primary essential in the elucidation of the general problem.

GERMINATION STUDIES OF AUSTRALIAN CHENOPODIACEAE WITH SPECIAL REFERENCE TO THE CONDITIONS NECESSARY FOR REGENERATION

I. ATRIPLEX VESICARIUM Heward

By Nancy T. Burbidge, B.Sc., Waite Agricultural Research Institute

Plate IV

[Read 10 May 1945]

Continued utilization of the arid pastoral country in Australia is likely to be impossible unless there is effective regeneration of the edible perennial shrubs, of which bladder saltbush, *Atriplex vesicarium,* is one of the most important. Natural regeneration does not take place with sufficient rapidity. Many factors are involved, but a study of the characteristics of germination is a primary essential in the elucidation of the general problem.

The majority of botanical studies carried out in arid regions have concentrated on the relations between the habitat and the plants, regardless of the age or maturity of the latter. Studies of germination, on the other hand, have been mainly concerned with viability tests, overcoming dormancy or increasing the rate of germination under incubator or field conditions. There is a definite gap in the knowledge of the behaviour of seed in its natural habitat.

The work described herein was undertaken to provide information regarding the field conditions necessary for regeneration following germination. Only in the laboratory can controlled experiments on germination be made, and although such experiments have their limitations they may contribute information basic to an understanding of the field problem. This paper is concerned with germination, but it follows that favourable conditions must continue long enough for the establishment of a root system which will reduce vulnerability to drought. The factors controlling such establishment cannot be discussed until further field work has been completed.

The Species

The plants are dioecious. There is no female perianth and the ovary is protected by two lateral, opposing and contiguous bracts. The ovule is flattened, it is campylotropous and basally attached, but the funicle is long and slender so that the mature seed has the micropylar protrusion pointed upwards. The condition is figured in the account of the family in Die Natürlichen Pflanzenfamilien (Volkens). See plate iv.

By the time the seed is mature the bracts have enlarged and become scarious, as have the dorsal spongy appendages. Occasionally the spongy tissue may be lacking on one or both bracts. This structure of two bracts and enclosed seed forms the fruit, from which the seed is not released except by decay of the bract tissue.

The ovary wall is thin and scarious and is ruptured by the developing embryo before the radicle succeeds in emerging through the micropyle. In its emergence the radicle splits the outer integument, and then the inner. Commonly there is a small cap of outer integument tissue isolated on the tip of the inner integument as it is pushed out by the radicle (see pl. iv, fig. 7-11). The elongation of the

hypocotyl pushes the cotyledons, as they withdraw backwards from the seed, above the soil.

The seed used in the experiments was collected at Whyalla in October 1943.

Methods

Various media have been used in researches on germination. The most familiar are absorbent paper, jelly culture media and sand. Sand was used for the experiments described below because it provides a more natural seedbed and also because preliminary experiments indicated that it would be less liable to fungal contamination over a three-week period. Germination was considered as accomplished when the hooped cotyledons and hypocotyl appeared through the sand. Under these circumstances the recording would reveal a delay if compared with germination of seed on the surface of a medium, when the emergence of the radicle would be the criterion. The chief disadvantage of the method used was that at high temperatures the plumule protruded above the sand soon after the emergence of the radicle, whereas at low temperatures there was a period of radicle development lasting a day or more before the plumule appeared.

It has been shown that duration of an experiment is important (2). Owing to the fact that the rate is retarded at low temperatures, the longer the experiments last the greater the germination at low temperature, or, in other words, the shorter the duration the higher the apparent optimum temperature will tend to be. Following preliminary tests a three-week period was decided upon.

The sand used was run through a 1 mm. sieve and oven-dried. The petri dishes used were of two sizes. The smaller (9·0 x 1·5 cm.) held 60 gms. of sand and the larger (10·0 x 2·0 cm.) held 100 gms. The dishes with the seeds and wet sand in position were weighed at the commencement of an experiment, and then watered up to weight at intervals throughout the test.

The incubators used were (a) a multiple temperature incubator with fourteen cabinets. The temperatures varied from 4°-40° C. in the winter months to 7°-42° C. in the summer, but during tests, temperature per cabinet rarely varied more than half a degree either way; (b) a Hearson germinator with a closed glass-topped lid.

Results

A. Effects of Temperature

A test was made to find the optimum temperature for germination. Seeds were germinated in the multiple temperature incubator. Two sets of dishes were used. In one the true seeds were removed from their bracts, and in the other there was no treatment. The sand was kept at 80% saturation. The results are shown in Table I, and Graphs 1 A and 1 B.

It will be noted that the removal of the seeds from their bracts had a considerable effect. The difference is probably due to the water- and air-holding capacity of the spongy tissue. Without the bracts the seeds have direct access to the soil moisture and air.

High temperatures appeared to have an inhibitive effect, whereas low merely decreased the rate of germination in both treated and untreated seed. The seedlings which appeared in the dishes at 36·5° C. and 30·5° C. died almost immediately and turned black. The petri dishes from the two highest temperature cabinets were kept at a lower temperature for some days following the test, but no germination occurred. Apparently the embryos had been permanently damaged. They had not merely failed to develop. The optimum temperature is somewhere near 16° if both amount and rapidity of germination are considered. The conclusion drawn from these results was that daily maximum temperatures might be expected to have a distinct effect upon germination. An experiment was accordingly designed to test this hypothesis.

Table I

Atriplex vesicarium germinated in multiple temperature incubator.
50 seeds per petri dish with sand at 80% saturation. Sum of two replications.

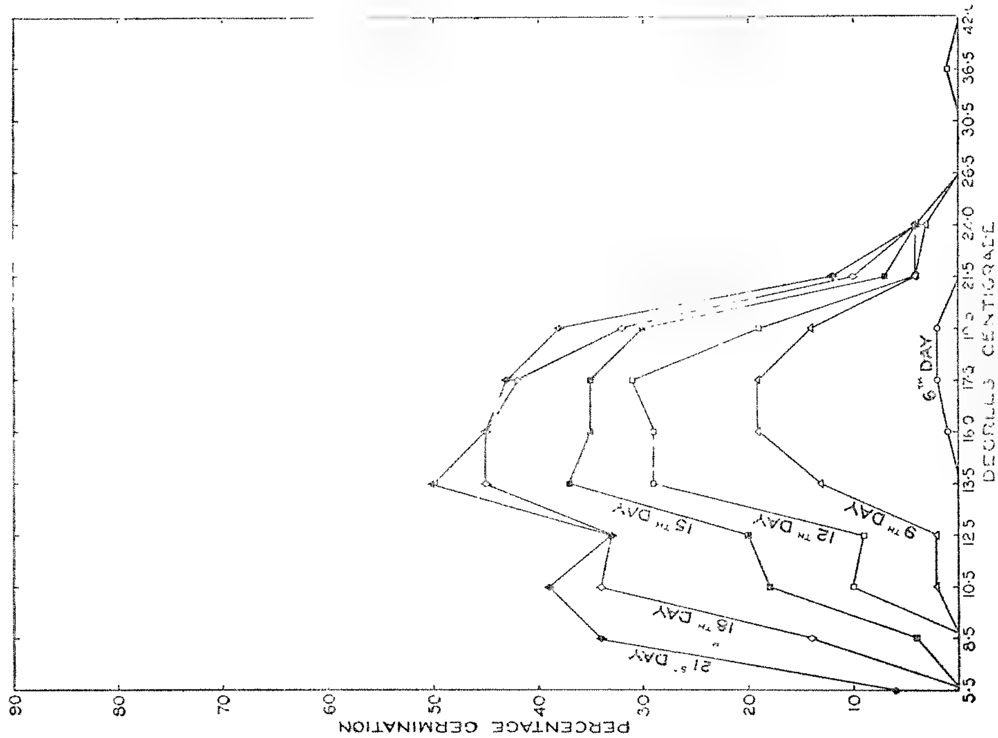
Mean Temperature °C.	Increase per 3-day period 3	6	9	12	15	18	21	Germination %
A. Seed removed from Floral Bracts:								
42·0	—	—	—	—	—	—	—	—
36·5	—	1	1	—	—	2	1	5
30·5	1	—	1	1	1	—	2	6
26·5	5	2	—	—	—	—	—	7
24·0	5	9	3	1	—	—	—	18
21·5	8	28	18	2	3	—	1	60
19·5	5	45	14	1	2	—	—	67
17·5	3	55	11	4	1	—	—	74
16·0	3	50	14	7	5	—	—	79
13·5	—	36	35	12	1	1	—	75
12·5	1	27	35	15	7	1	1	87
10·5	—	14	41	21	4	6	3	89
8·5	—	1	27	21	15	11	5	80
5·5	—	—	2	6	17	20	20	65
B. Seed in Floral Bracts:								
42·0	—	—	—	—	—	—	—	—
36·5	—	—	—	1	—	—	—	1
30·5	—	—	—	—	—	—	—	—
26·5	—	—	—	—	—	—	—	—
24·0	—	—	3	1	—	—	—	4
21·5	—	—	4	—	3	3	2	12
19·5	—	2	12	5	11	2	6	38
17·5	—	2	17	12	4	7	1	43
16·0	—	1	18	10	6	10	—	45
13·5	—	—	13	16	8	8	5	50
12·5	—	—	2	7	11	13	—	33
10·5	—	—	2	8	8	16	5	39
8·5	—	—	—	—	4	10	20	34
5·5	—	—	—	—	—	—	6	6

Maximum Temperature Experiment 1

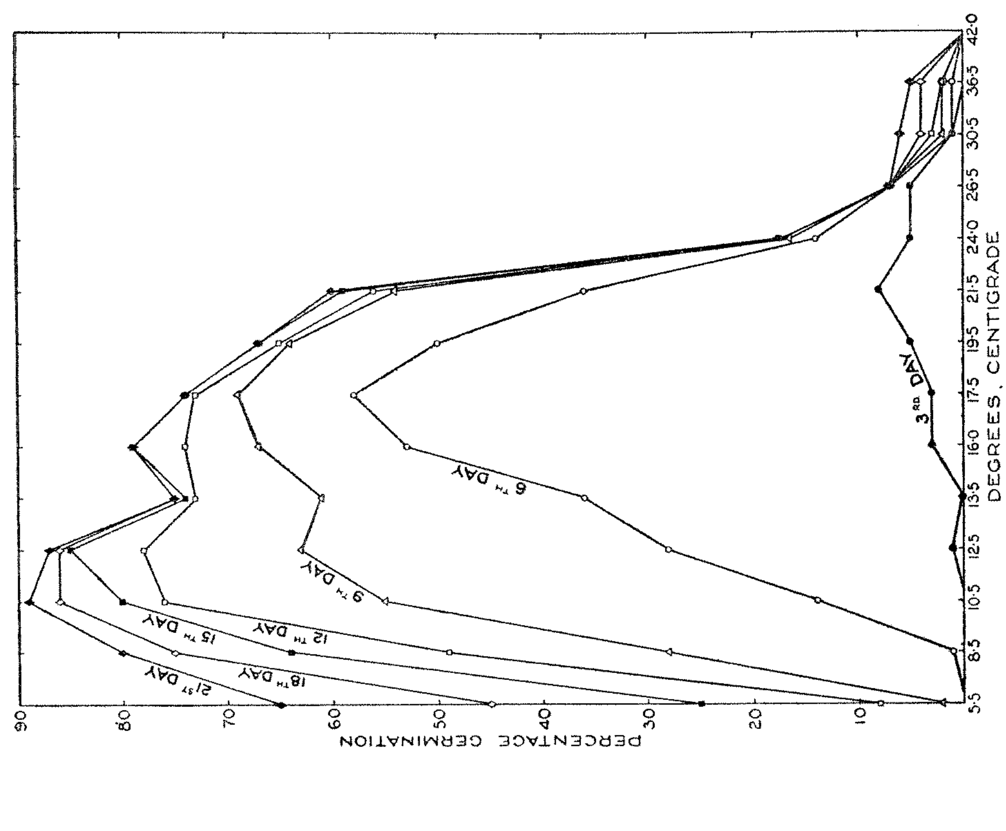
Two sets of three petri dishes each were run through a series of temperatures during the day and left overnight at a low temperature. Each dish was planted with 50 seeds in their bracts, and the sand was saturated to 60% of the water-holding capacity. Each set of dishes followed a definite schedule of temperature changes. The aim was to have a gradual daily rise to a two-hour maximum period. Two control dishes were present in each cabinet used.

Schedule A_1:		Schedule B_1:	
17° C. from	9.00 – 9.30 a.m.	12.5°C. from	9.00 – 9.30 a.m.
21° C. „	9.30 – 10.00 a.m.	15.5°C. „	9.30 – 10.00 a.m.
26° C. „	10.00 – 11.00 a.m.	18.5°C. „	10.00 – 11.00 a.m.
36° C. „	11.00 – 12.00 noon	23° C. „	11.00 – 12.00 noon
41.5°C. „	12.00 – 2.00 p.m.	30° C. „	12.00 – 2.00 p.m.
36° C. „	2.00 – 3.00 p.m.	23° C. „	2.00 – 3.00 p.m.
26° C. „	3.00 – 4.00 p.m.	18.5°C. „	3.00 – 4.00 p.m.
21° C. „	4.00 – 4.30 p.m.	15.5°C. „	4.00 – 4.30 p.m.
17° C. „	4.30 – 5.00 p.m.	12.5°C. „	4.30 – 5.00 p.m.
13.5°C. „	5.00 p.m. – 9.00 a.m.	7° C. „	5.00 p.m. – 9.00 a.m.

The range of temperature represented by these schedules is greater than would occur naturally over a three-week period, but ranges of 20°-25° C. in daily air temperatures are commonly recorded during hot spells in December, January or February, in saltbush areas. In the soil the range would be greater. Since it was intended to test the hypothesis that high soil temperatures during the summer



Graph 1 B



Graph 1 A

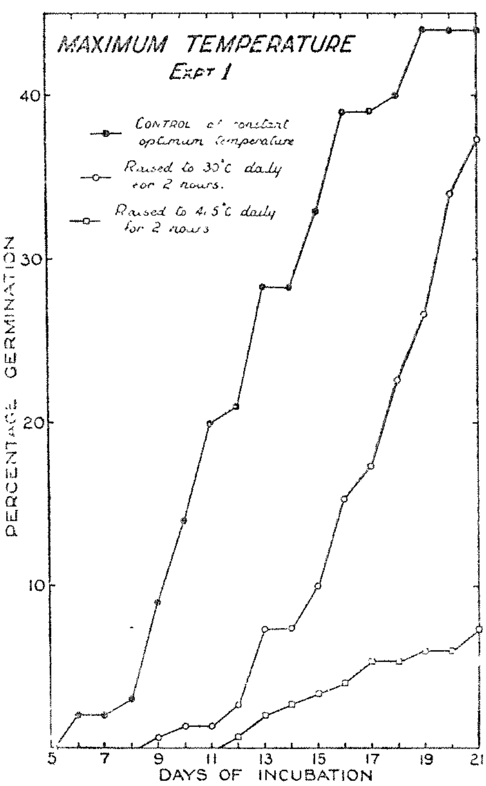
months would inhibit germination even after heavy rains, the range used is not excessive. The results are shown in Table II, and Graph 2.

TABLE II

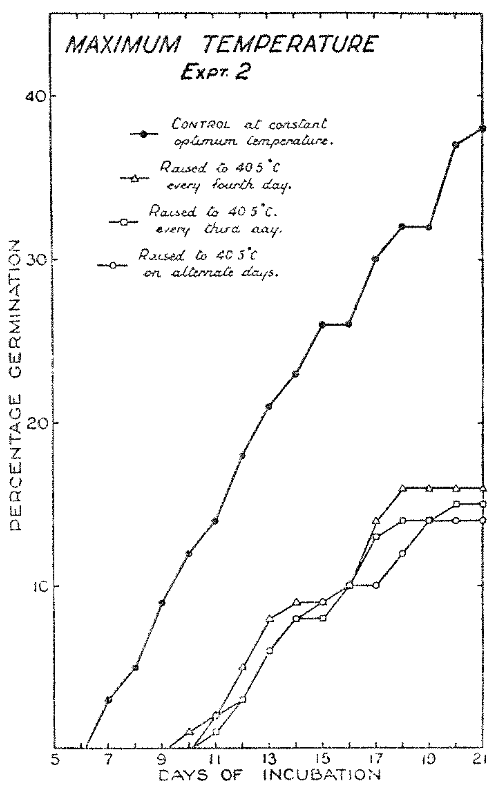
Maximum temperature experiment 1.

50 seeds per petri dish with 60 gms. of sand at 60% saturation.

Mean Temperature °C.	Increase per 3-day period: 3	6	9	12	15	18	21	% Germination
Schedule A_1 (sum of three replications):	—	—	—	1	4	3	3	7·3
Schedule B_1 (sum of three replications):	—	—	1	3	11	19	22	37·3
Controls (sum of two replications):								
41	1	—	—	—	—	—	—	1·0
36·5	—	—	—	—	1	—	—	1·0
30	—	—	—	—	—	—	—	nil
26	—	—	—	—	—	—	—	nil
23	—	—	—	—	—	—	—	nil
21	—	—	1	3	4	2	1	11
18·5	—	2	3	3	9	3	1	21
17·0	—	2	7	12	12	7	4	44
15·5	—	1	6	6	1	9	7	30
13·5	—	—	6	5	10	5	3	29
12·5	—	—	3	13	13	6	2	37
7	—	—	—	—	—	8	10	18



Graph 2



Graph 3

Raising the dishes to 41·5° C. for two hours per day reduced the ultimate germination to 7% as compared with 44% at 17° C., but raising the dishes to 30° C. did not reduce the final result to any significant extent. However, it will be seen in the graph that germination was definitely retarded. The retardation appears to be due to the high temperature effect rather than the normal low temperature delay, since the effect is stronger with the dishes following Schedule A_1 than it is in B_1 where the dishes were kept overnight at 7° C.

Having shown that a maximum temperature would affect the germination rate, further experiments were carried out on similar lines.

Maximum Temperature Experiment 2

SCHEDULE A_2—Dishes passed from 13·5° C - 30·5° C. and back during the hours 9 a.m. - 5 p.m., but on alternate days were raised to 40·5° C. for one hour.

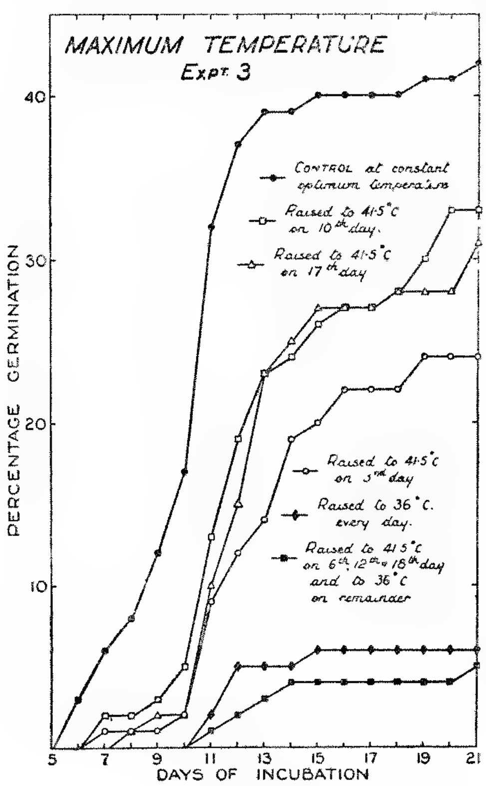
SCHEDULE B_2—As in A_2, but dishes raised to 40·5° C. every third day.

SCHEDULE C_2—As in A_2, but dishes raised to 40·5° C. every fourth day.

The results can be seen in Graph 3. The high temperature effect is not so pronounced as in the first experiment, and there is no significant difference between the three treatments.

Maximum Temperature Experiment 3

Five sets of two dishes each were incubated according to the following schedules. Dishes were prepared as before and there were the usual controls. The usual number of temperature changes was used.



Graph 4

SCHEDULE A_3—Dishes passed from 15° C. - 32° C. between 9 a.m. and 12 noon and back between 2 p.m. and 5 p.m. except on the third day, when they were raised to 41·5° C. for one hour.

SCHEDULE B_3—As in A_3, but raised to 41·5° C. on tenth day only.

SCHEDULE C_3—As in A_3, but raised to 41·5° C. on seventeenth day only.

SCHEDULE D_3—From 16° C. raised to 36° C. every day for two hours and returned to the low temperature for the night.

SCHEDULE E_3,—As in D_3, but raised to 41·5° C. for one hour on sixth, twelfth and eighteenth days of incubation .

The results are seen in Graph 4. It will be noted that raising to 36° C. both depressed and retarded germination, *c.f.*, Graph 2. Owing to this, no effect of raising to 41·5° C. on every sixth day (E_3) can be diagnosed. In A_3, B_3 and C_3, raising to 41·5° C. on the third day has had more effect than raising on either the tenth or the seventeenth day, but the effect has been to lower the final result rather than to retard the onset. The final results of B_3 and C_3 are

close to that of B_1 in the first experiment. Apparently the germination rate is not seriously affected by a high temperature occurring ten or more days after the moistening of the soil.

B. Effects of Soil Saturation

The problem of germination in an arid habitat is twofold. A species must be able to utilise moisture as soon as it is available, but the seeds must not be so sensitive that they respond to light showers which moisten the soil surface for a few hours.

Two experiments were carried out to find the optimum saturation for germination. The first test was at 23·5° C. The levels of saturation were 20%, 40%, 60%, 80% and 100% water-holding capacity. Each petri dish (10 x 2 cm.) held 50 seeds in 100 gms. of sand. There were two series of dishes; one with the seeds removed from their bracts and the other with untreated seed. Each series was duplicated. So far as the amount of germination was concerned, this test was a failure, but it supports the conclusion that *Atriplex vesicarium* requires a cool season for germination, and hence regeneration. The results are shown in Table III.

Table III

Effect of varying soil saturation at 23·5° C. Sum of two replicates of 50 seeds.

Saturation %	Increase per 3-day period 3	6	9	12	15	18	21	% Germination
A. Seeds removed from bracts:								
20	—	1	3	2	1	—	1	8
40	3	4	1	2	2	1	2	15
60	4	5	7	6	4	1	1	28
80	4	8	7	5	2	2	1	29
100	4	8	1	3	4	1	1	22
B. Seeds in floral bracts:								
20	—	—	1	—	2	—	—	3
40	—	—	—	—	—	—	—	—
60	—	1	2	1	—	1	—	5
80	—	1	2	1	1	—	1	6
100	—	—	—	1	—	—	—	1

The test was repeated at 18° C and the results compared satisfactorily with those of the temperature experiment. See Table IV.

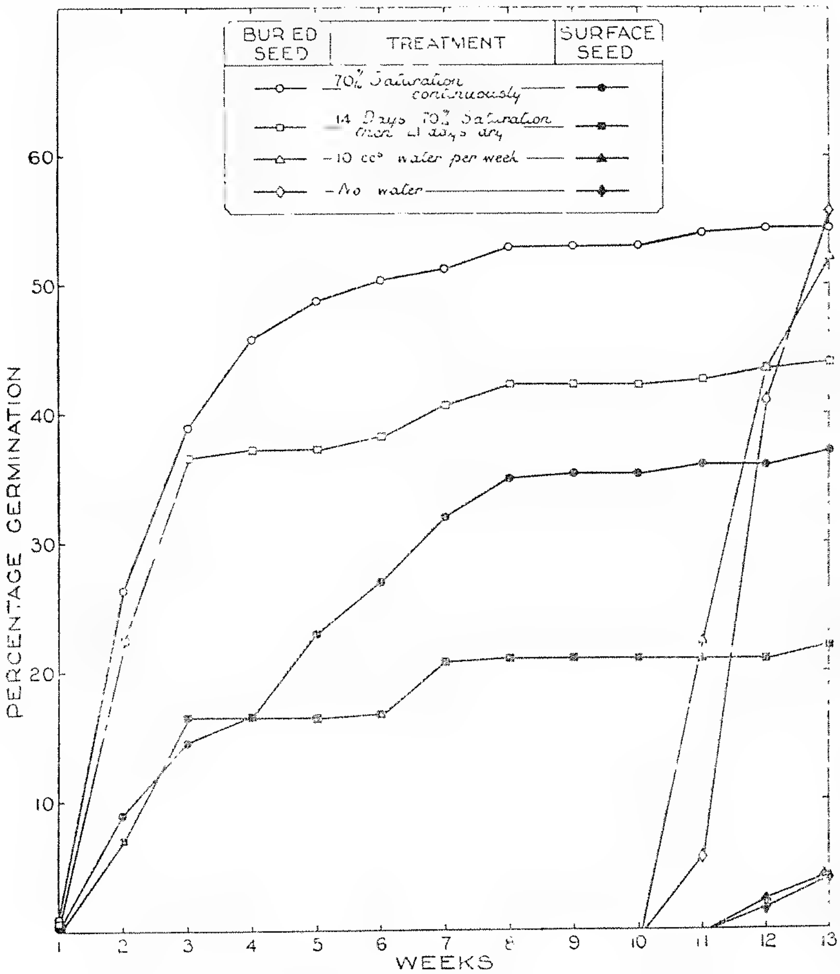
Table IV

Effect of varying saturation at 18° C. Sum of two replicates of 50 seeds.

% Saturation	Increase per 3-day period 3	6	9	12	15	18	21	% Germination
A. Seeds removed from bracts:								
20	—	35	26	10	7	—	—	78
40	3	38	29	12	3	—	—	85
60	2	58	25	6	1	—	—	92
80	7	43	22	8	2	—	—	82
100	1	32	25	9	4	—	—	71
B. Seeds in floral bracts:								
20	—	—	4	2	3	1	4	14
40	—	—	8	8	5	1	—	22
60	—	6	16	9	6	3	—	40
80	—	1	17	11	8	1	—	38
100	—	6	16	9	7	3	—	41

It will be noted that 60% gave the best results. In the treated seed at 18° C. the result is significantly better than all other saturations. In the untreated seed there is no significant difference between 60%, 80% and 100%. It is believed that this is due to the soil aeration factor. At high saturations aeration is poor —hence the result with treated seed. When the bracts are present, the spongy tissue retains bubbles of air which would be available to the developing seed.

It was suspected that at low saturation the water-absorbing capacity of the spongy tissue of the bracts would compete with that of the seeds. To check this, seeds whose bracts had spongy appendages were tested against those without. The seeds were placed on the surface of sand moistened to 60% saturation in



Graph 5

10 x 2 cm. petri dishes. Germinations of 34% and 35·3% were obtained. Seeds buried in sand and seed on the surface were also tested in a saturated atmosphere. There was no significant difference in the results, but the tests are inconclusive.

An experiment under glasshouse conditions was planned, using flat tins 15 x 6 cms., each holding one kilogram of sand and planted with 100 seeds. The tins were arranged as follows:

Series 1 watered to 70% saturation continuously.
,, 2 watered to 70% saturation 2 weeks and left dry 3 weeks alternately.
,, 3 given 10 ccs. water once a week.
,, 4 left dry.

In each series, half the tins had buried seeds and half had seeds scattered on the surface. There were three replications.

Treatments continued for ten weeks (9th June - 10 August), after which all tins were brought to the 70% saturation level for three weeks.

The results are seen in Table V and Graph 5.

TABLE V

Effect of various watering treatments under glasshouse conditions.

Treatment	% germin. 1st week	% germin. 2nd week	% germin. 3rd week	% germin. 4-10th week	% germin. 11th week	% germin. 12th week	% germin. 13th week	Total %
Continuous 70% saturation—buried seed -	1·7	23·0	13·0	15·3	1·0	0·3	—	54·3
Continuous 70% saturation—surface seed -	0·3	8·0	6·0	21·3	0·7	—	1·0	37·3
14 days 70% 21 days dry—buried seed -	0·7	20·0	14·3	7·3	0·3	1·0	—	43·7
14 days 70% 21 days dry—surface seed -	0·3	6·0	8·7	6·0	—	—	1·0	22·0
10 ccs. water per week—buried seed -	—	—	—	—	5·7	35·3	11·3	52·3
10 ccs. water per week—surface seed -	—	—	—	—	—	2·0	2·3	443
No water—buried seed -	—	—	—	—	2·7	35·3	18·0	56·0
No water—surface seed -	—	—	—	—	—	1·7	2·6	4·3

In all cases buried seed is superior to seed scattered on the surface. Intermittent watering caused a setback in the fourth week, from which there was no full recovery (see graph 5). Series 3, with 10 ccs. water per week (equivalent to a heavy dew), did not show any deterioration of the seed due to treatment. Germination of the buried seed in Series 3 and 4 was more rapid than in Series 1 and 2, due to the more propitious August temperature. The poor germination of the surface seed in Series 3 and 4 was found to be due to the higher evaporation under the August temperatures. The seeds were covered with sand and watered to the 70% saturation level. The resulting germination was extremely good.

In a second glasshouse experiment, the planting treatments were:

(1) Buried seed; (2) Surface seed; (3) Seed covered by 2·5 cm. of litter composed of twigs and leaves of *Acacia Sowdenii;* (4) Seed on surface but shaded with sacking from 10 a.m. - 4 p.m. (to imitate shading by a shrub during the hottest portion of the day).

There were three watering treatments:

(a) 40 ccs. water per week; (b) 20 ccs. per week; (c) left dry.

The test ran for eight weeks (15 September - 10 November), after which the tins were brought to the 70% saturation level for 21 days. There were three replications. The results are shown in Table VI.

TABLE VI

Effect of various planting and watering treatments under glasshouse conditions.

Planting Treatment	% germination 40 ccs. water per week	20 ccs. water per week	No water
Buried Seed - - -	46·0	56·7	49·7
Surface seed - - - -	4·3	2·0	1·0
Seed under litter - - -	9·7	2·7	2·3
Surface seed shaded— 10 a.m. – 4 p.m. - -	4·0	1·7	3·3

The buried seeds were overwhelmingly superior. The seeds under litter were disappointing. With 40 ccs. per week one replication gave 21%, the others 6% and 2%. The seeds lay between the sand and the litter. Under natural conditions they would be covered with drift sand, which would filter through the twigs. The differences due to watering treatments were not significant.

C. THE EFFECT OF SATURATION x TEMPERATURE

Four saturation levels (40%, 60%, 80% and 100%) were tested at the following temperatures, 29° C., 25° C., 22° C., 17·5° C., 14·0° C., in the multiple temperature incubator. There were 50 seeds per petri dish (9 x 1·5 cm.) with 60 gms. of sand. There were two replications. The results are shown in Table VII.

TABLE VII

Temperature x saturation — % germination.

Temperature ° C.	Saturation 40%	60%	80%	100%
29·0 - -	—	2	—	1
25·0 - -	—	2	1	—
22·0 - -	5	4	14	26
17·5 - -	28	51	52	48
14·0 - -	34	45	49	64

It would appear that both above and below the optimum temperature germination is improved by a rise in the saturation level. At 17·5° there is no significant difference between the results at 60%, 80% and 100% (*c.f.*, Table IV).

D. DEPTH OF PLANTING

To test the ability of *Atriplex vesicarium* to germinate in sand drifts, seeds were planted at 4″, 3″, 2″, 1″, ½″ and on the surface of sand in 800 cc. beakers which were enclosed in bands of black paper. Incubation was at 20° C., this being the lowest temperature available in the Hearson incubators in November.

The results were:

4″ - no germination	2″ - - 1·3%	½″ - - 32·7%
3″ - ,, ,,	1″ - - 21·3%	Surface - 17·3%

Examination of the seeds showed that germination had taken place in all beakers, but at 2″ or deeper the hypocotyls were not capable of sufficient elongation to push the cotyledons above the surface. It is evident that the seeds of this species would not survive for long in a wet sand drift, and only under exceptional conditions could they colonise such a habitat.

DISCUSSION

It should be emphasised that the results represent germination under experimental conditions over a 21-day period. The manner in which germination takes place and the appearance of a few seedlings each day over most of the period, is in accordance with field observations and agrees with germination in pots under

glasshouse conditions with no control of temperature. This feature appears to be characteristic for the species. It also occurred in preliminary experiments on *Atriplex spongiosum*, but not *Atriplex semibaccatum*, so that the position in the remainder of the genus requires further study. Trumble (6) reported that at optimum temperature and saturation most of the seeds of *Atriplex semibaccatum* germinate in the first week.

Evidence concerning the longevity of *Atriplex vesicarium* seed under natural conditions is slight. The glasshouse experiments show that deterioration due to light showers, which are a feature of arid climates, is not particularly important. Under storage conditions at the Waite Institute the seed has not been seriously affected over the period 1936-43, but the results are not conclusive. Insect damage in the field probably plays a very important part.

It was found (1) that germination of the seeds of desert winter annuals was improved by alternating temperatures of 10° - 30° C. for 18 and 6 hours respectively. The seeds of these species are shed early in summer, but the high temperatures of the next few months inhibit germination, which commences during the following winter. However, by the next summer, dormancy has apparently been overcome, and early summer rains could bring up seedlings, since higher temperatures are now tolerated in tests. In *Atriplex vesicarium* there is no evidence that any period of dormancy exists. Such a period is unlikely because the seed coat is thin, there is little endosperm, and the embryo is well developed when the seed is shed.

The method of overcoming dormancy by alternations of temperature is widely practised in the United States of America. With Australian plants it has not been successful. It has been used in *Danthonia pilosa* (5), *Stipa nitida* (4) and *Astrebla lappacea* (3), but without any appreciable improvement in results. The method is most likely to succeed with seeds having a marked after-ripening or dormant period. Seeds of plants growing under climatic conditions where there are marked seasons and seasonal changes are more likely to show such a period than the seeds of plants growing under Australian conditions, where the transition from season to season is not so pronounced.

The maximum temperature experiments were designed to study the effect of high daily maxima during germination. The results show clearly that temperatures above 30° C. are likely to be highly injurious to the developing embryo. The indications are that high temperatures do not merely inhibit germination but that when moisture is present the physiological processes are disturbed, causing injury to the tissues. In this event, high temperatures following summer rains must be responsible for a considerable amount of damage to the seed reserves in the soil.

There was no indication that any combination of temperature changes gave a better rate of germination than that at the optimum temperature, even though it has been found (7) that naturally fluctuating temperatures have a beneficial effect in some species.

It follows from the experiments that good regeneration of saltbush is unlikely to occur after a heavy summer rain. However, there are a number of reports that satisfactory regrowth has taken place after an autumn rain. A study of the meteorological records of a locality in the saltbush areas shows that in February, March and early April the daily maximum air temperature is likely to be dangerously high for germination of saltbush. But after a heavy rain the temperature falls suddenly and may stay down below the danger level for several weeks. If this "danger level" be hypothetically fixed at 85° F. (29° C.), then it is found that temperatures very rarely fall for a long enough period in February, occasionally do in March and always do in April. Thus two inches of rain in one

March may be followed by cool weather, and in another by hot, so that the weather following the rain has a profound effect on germination.

Early summer rains do not have the same effect on air temperatures which are still low following the cool season, which makes a sudden drop unlikely. Also, the temperatures are on the up-grade with the approach of summer. Speaking generally, September corresponds with April and October-November with March, but since conditions grow daily more severe, as the summer drought approaches, seedlings resulting from any rain will probably be scorched off very rapidly.

The climate of the saltbush areas is characterised by the irregular and erratic rainfall. There is no definite wet season. But bladder saltbush requires a cool, wet season for germination, and hence regeneration. The amount of precipitation in any one year may be very satisfactory, the herbage produced may be good, but if the temperature is wrong during the period immediately following the chief rains then regeneration of the perennial bladder saltbush will be disappointing.

Summary

Incubated at constant temperature the optimum range for germination of *Atriplex vesicarium* is approximately 14-18° C. over a period of 21 days.

Removal of seed from the bracts widens the range tolerated and increases the rate and amount of germination.

Daily maximum incubating temperatures of over 30° C. have a lowering effect on the germination rate.

The effects of raising to a temperature above 30° C. for various numbers of days is described. In all cases the germination rate is lower than that at the optimum temperature.

When seeds are removed from their bracts, sand saturated to 60% of water-holding capacity gave best results at optimum temperature. If left in bracts, there was no significant difference between 60%, 80% and 100%.

Seeds buried in sand gave better germination than those on the surface except in a saturated atmosphere.

In glasshouse tests, light weekly waterings did not result in any seed deterioration.

When seeds were planted more than 2" deep no seedlings succeeded in reaching the surface. Best results were obtained from seed planted at ½".

It is concluded from the results that regeneration of *Atriplex vesicarium* is not likely to occur after summer rain, and that hot days following such rain may cause considerable damage to the seed reserve in the soil.

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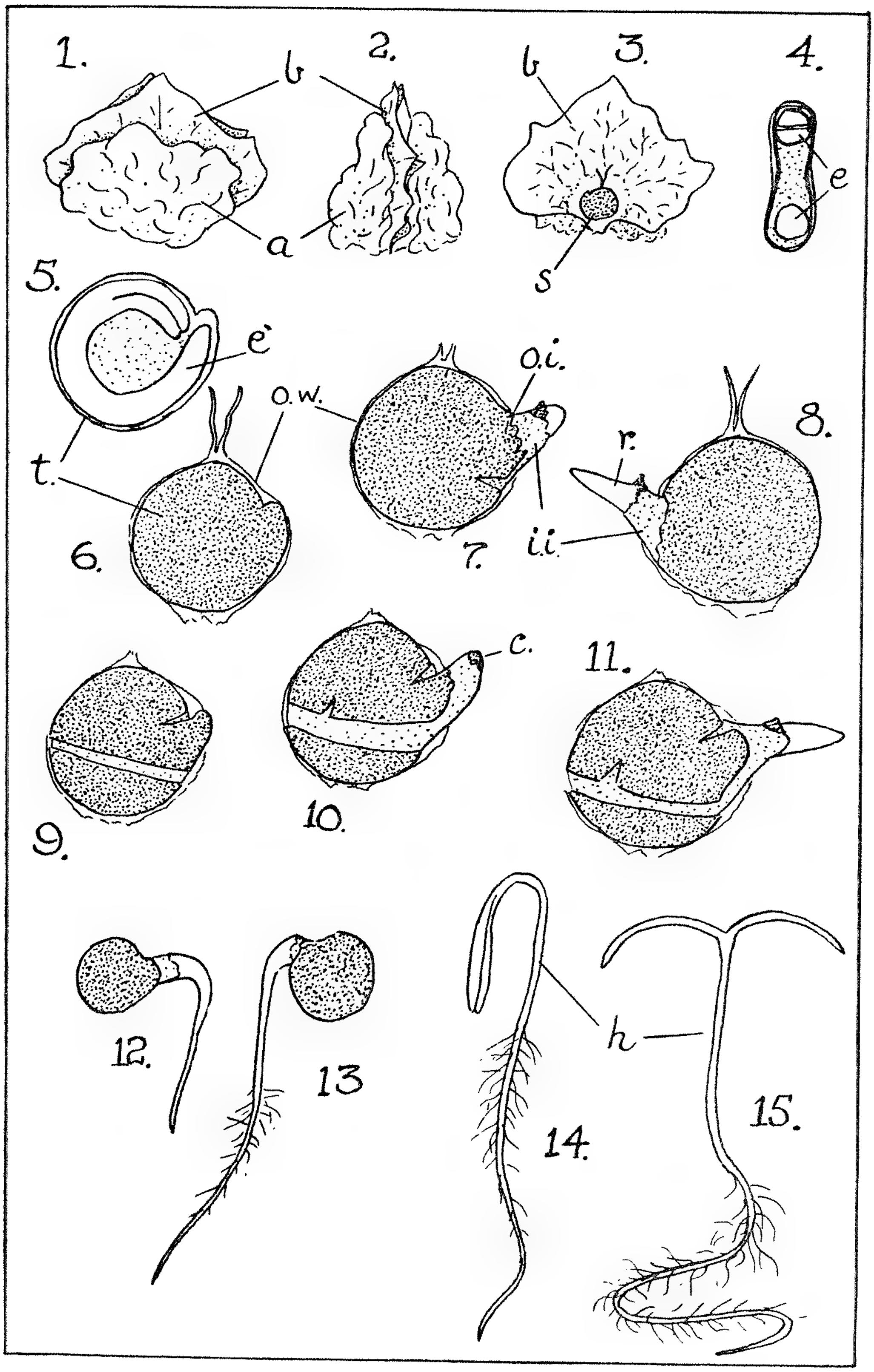
DESCRIPTION OF PLATE IV

Fig. 1-2: Fruit: a, appendage; b, bract. 3, Bract, showing inner face and attached seed(s). 4, Vertical section of seed, showing embryo and endosperm. 5, Same cut in another position: t, testa; e, embryo. 6-13, Stages in germination: o.w., ovary wall; o.i., outer integument; i.i., inner integument; c, cap of outer integument tissue. 14-15, Young seedlings: h, hypocotyl. Fig. 1-11, x 10 ca.; 12-15, x 5 ca.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AUSTRALIAN CUMACEA, NO. 10 THE FAMILY LEUCONIDAE

BY HERBERT M. HALE, DIRECTOR, SOUTH AUSTRALIAN MUSEUM

(READ 10 MAY 1945)

Summary

The most northerly record of the family in the southern hemisphere seems to be that of *Leucon calluropus* Stebbing (1912, p.156 – off Natal, South Africa, latitude about 29° S, longitude 32° E). Calman (1907, 31-39) records seven species from the south island of New Zealand (latitude 43 ° - 44° S., longitude 173° E); this fairly good representation was secured in a small area, evidently by the same collector, H. Suter, in May and August 1897. About ten of the other known species occur in the Subantarctic and Antarctic.

AUSTRALIAN CUMACEA, No. 10[1]
THE FAMILY LEUCONIDAE

By HERBERT M. HALE, Director, South Australian Museum

[Read 10 May 1945]

Fig. 1-6

Family LEUCONIDAE

The most northerly record of the family in the southern hemisphere seems to be that of *Leucon calluropus* Stebbing (1912, p. 156—off Natal, South Africa, latitude about 29° S., longitude 32° E.). Calman (1907, 31-39) records seven species from the south island of New Zealand (latitude 43°-44° S., longitude 173° E.); this fairly good representation was secured in a small area, evidently by the same collector, H. Suter, in May and August 1897. About ten of the other known species occur in the Subantarctic and Antarctic.

It would seem that Leuconids play but a small part in the Cumacean fauna of Australian coasts, although the southern waters of Tasmania may produce somewhat different results. Notwithstanding the fact that some extensive collections have been made off New South Wales and South Australia, individuals belonging to the family number less than fifty, and represent only three species. These were secured between latitude 35°-36° S., two from the east coast (longitude 150°-152° E) and one from the south (longitude 138° E.). All are herein described as new; two are referred respectively to *Leucon* and *Hemileucon*, but if they are to remain so placed some latitude in the definition of these genera must be allowed.

Genus LEUCON Kröyer

Leucon, Kröyer, 1846, 208; Stebbing, 1913, 63 (syn.); Hansen, 1920, 7.

Kröyer's name has been long quoted for this widely distributed Cumacean genus and the discarding of *Leucon* because it has been used in Besser MS. (Schoenherr, 1834, Gen. Curc., 2, (1), 285, 286) for the Coleoptera would serve no useful purpose.

Leucon ocularis sp. nov.

Adult male (A). Carapace smooth, excepting for faint, sparse pitting and a feeble median carina on frontal lobe; it is a little longer than the pedigerous somites together and more than one-fourth of total length of animal; it is slightly compressed and with greatest width more than half its length. Pseudorostrum not at all upturned; lobes meeting for a distance equal to about one-seventh of length of carapace, in front subtruncate, serrate and fringed with setae. Ocular lobe not distinctly defined, but there is present a small projection at apex of frontal lobe; eye present, there being a large sooty patch on frontal lobe, surrounding a single, oval, tumid corneal lens. Antennal notch widely open; the antero-lateral margin and front part of infero-lateral margin of carapace serrate.

Pedigerous somites somewhat depressed, the pleural parts of first to fourth rather prominent; second to fourth subequal in length.

Pleon distinctly longer than cephalothorax; first to fifth somites successively increasing in length; telsonic somite short, as long as second somite; as wide as long, and with posterior margin rounded and bisinuate; the produced distal part is one-half the length of the remainder.

First antenna with second and third joints of peduncle subequal in length, together as long as first joint; flagellum almost as long as last peduncular seg-

[1] No. 9, see Rec. S. Aust. Mus., 8, 1945, pp. 145-218, fig. 1-49.

ment, two-jointed, the first segment seemingly composed of two fused joints; accessory flagellum large, single-jointed, as long as first segment of main lash.

Flagellum of second antenna reaching to just beyond end of telsonic somite.

Mandible typical of genus; lacinia stout and bidentate.

Third maxilliped with basis more than half as long again as palp.

Basis of first peraeopod barely longer than rest of limb; carpus slightly longer than ischium and merus together; propodus a little shorter than carpus and longer than dactylus.

Second peraeopod with basis longer than rest of limb; ischium short but distinct; carpus with three unequal distal spines; dactylus twice as long as propodus, and not quite as long as the longest of its five distal spines.

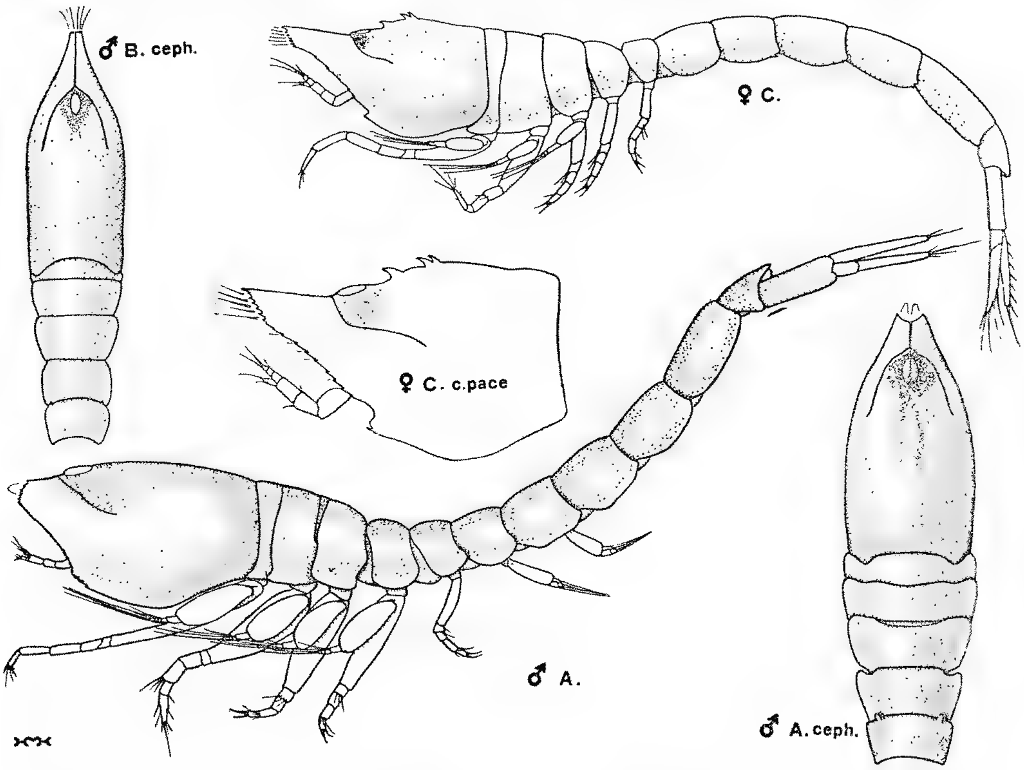

Fig. 1 *Leucon ocularis*. A, Lateral view and (ceph.) cephalothorax of type male, Backstairs Passage. B. ceph., Cephalothorax of male from St. Vincent Gulf. C, Lateral view of allotype female, St. Vincent Gulf (all x 37); C. c, pace, Carapace of allotype female (x 60).

Third and fourth peraeopods with basis wide and more than twice as long as rest of limb; ischium subequal in length to merus and with three unequal setae; carpus not much longer than propodus, with three distal setae, the longest reaching level of tip of dactylus.

Fifth peraeopod abruptly shorter, only about half length of fourth; basis not expanded, barely longer than rest of limb.

Peduncle of uropod shorter than the subequal rami, and with half-a-dozen plumose setae and a few shorter outstanding stiff setae; exopod with three unequal spines at truncate apex, the longest almost half as long as the ramus, its inner margin with three plumose setae and a spine next to the terminal three; endopod single-jointed, with two stout unequal distal spines (the longer less than

half as long as ramus) and with a row of about a dozen short spines on whole length of inner margin.

Colour white save for the pronounced pigmentation of the frontal lobe; this colour patch bifurcates behind the lobe and extends for some distance along the back. Length 2·8 mm.

Loc.—South Australia: Page Islands, Backstairs Passage, 9 fath. (K. Sheard, submarine light, Apl. 1941). Type, male, in South Australian Museum, Reg. No. C.2493.

Males only were taken at this locality.

Adult male (B). Carapace distinctly longer than pedigerous somites together and with its greatest width much less than half its length; it is little more than one-fourth of total length of animal. Pseudorostrum narrowly truncate in

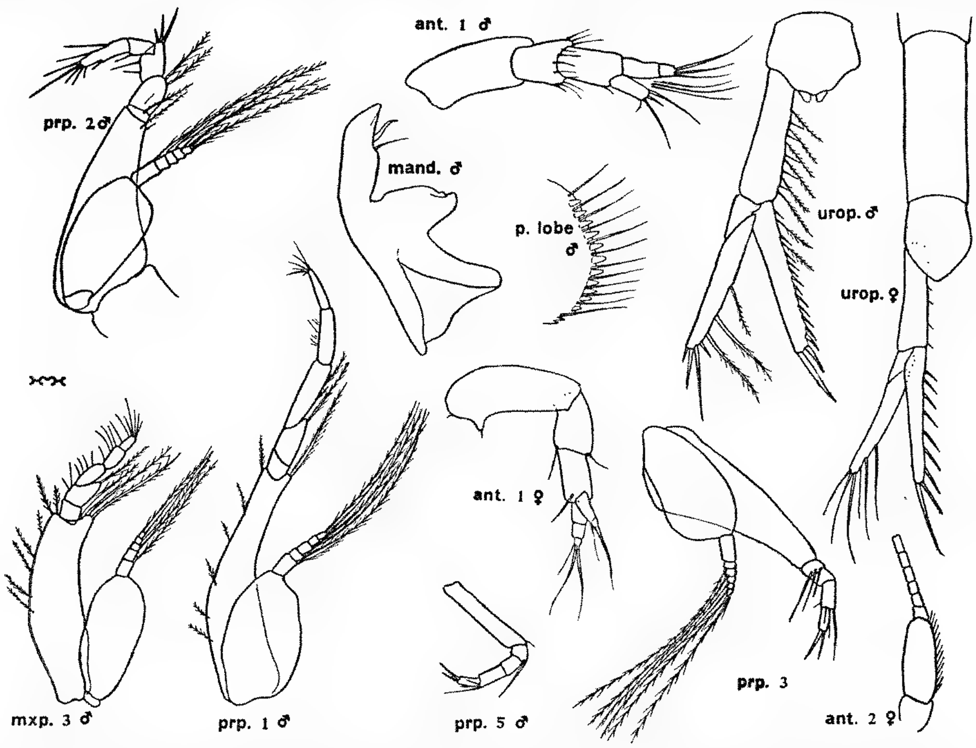

Fig. 2 *Leucon ocularis*, paratype adult male from Backstairs Passage, and allotype female from St. Vincent Gulf; p. lobe, mand. and ant. 1, anterior end of pseudorostral lobe, mandible and first antenna (x 135); ant. 2, and prp, part of second antenna and peraeopods (x 60); urop, uropod with telsonic somite, etc. (x 60).

front, the lobes meeting for a distance equal to nearly one-fourth of length of carapace. Frontal lobe and eye as described (fig. 1, B). Pleon barely longer than cephalothorax, slender as in the female shown in fig. 1, C.

Second antenna with flagellum reaching beyond end of pleon for a distance equal to length of telsonic somite.

Length 2·7 mm.

Loc.—South Australia: St. Vincent Gulf, off Troubridge Island, near Edithburgh, 10½ fath. (H. M. Hale and K. Sheard, A. Trawl, Apl. 1945).

This male, taken in more sheltered waters than the examples from Backstairs Passage, agrees in essential features with the latter but differs strikingly in the much more slender form and the longer and narrower pseudorostrum.

Subadult female (C). Carapace more than one-fourth of total length of animal, decidedly compressed, and one and three-fourths times as long as deep; mid-line of dorsum with three teeth, one placed posterior to eye at middle of length, the other two very close together a little behind this. Pseudo-rostrum horizontal, the lobes meeting for a distance equal to more than one-fourth of length of carapace; seen from the side the lobes are very obliquely subtruncate and finely serrate in front; the oblique antero-lateral margin leading to the small but distinct antennal notch is feebly serrate; antero-lateral angle rounded, with a small tooth inferiorly, and margin posterior to this very feebly serrate. A large lens and dark colour patch on frontal lobe as in male, the pigment mass embracing several pale oval areas.

Pleon barely longer than cephalothorax; fifth somite about twice as long as telsonic somite, which is longer than wide and is well produced posteriorly above bases of uropods.

Main flagellum of first antenna apparently three-jointed, and accessory lash two-jointed, the second segment minute.

Basis of first peraeopod shorter than in male, not as long as remaining joints together.

Second peraeopod with basis equal in length to rest of limb; the ischium, although distinct in the male, cannot be made out here.

Third and fourth peraeopods not much longer than fifth.

Peduncle of uropod nearly four-fifths as long as the subequal rami and with a few short and feeble inner setae, but no plumose hairs; endopod single-jointed, with seven spines on inner margin and two terminal ones, the longer of which is fully half as long as the ramus.

Length 2·65 mm.

Loc.—South Australia: St. Vincent Gulf, off Troubridge Island, near Edithburgh, 10½ fath.; and midway between Edithburg and Glenelg, 35 metres (H. M. Hale and K. Sheard, A. Trawl, Apl. 1945). Allotype female in South Australian Museum, Reg. No. C. 2757.

In some Cumacea with well-developed eye the corneal lenses are not confined to the portion of the frontal area separated off as an ocular lobe (see for instance *Glyphocuma bakeri* Hale, 1944, fig. 31); further, an ocular lobe is not necessarily sharply marked off in species with eyes (see *Gephyrocuma repanda* Hale, 1944, fig. 16). Some of the species of *Leucon* are regarded as having a small and obscure eye-lobe, like the tiny anterior projection of the frontal lobe of *ocularis*. In Zimmer's *kerguelensis* (1908, 178, pl. xli, fig. 71-72) this is larger and quite distinct.

Apart from the presence of a pigmented eye, *ocularis* differs from all other species referred to the genus in having the endopod of the uropod not divided into two segments.

Genus Hemileucon Calman

Hemileucon Calman, 1907, 32 and 37; Stebbing, 1913, 152.

The only species previously referred to the genus are the two from New Zealand described by Calman—*uniplicatus* and *comes*. The form recorded below differs from both of these in having the endopod of the uropod single-jointed and in lacking lateral ridges on the carapace; it would appear that latitude in these characters will have to be allowed in Leuconid genera, as it is in *Bodotria* and *Gynodiastylis*. The new species agrees with *comes* in having the ischium of the second peraeopod distinct.

The genus stands on male characters, the complete absence of pleopods and a second antenna with short flagellum.

Hemileucon levis sp. nov.

Ovigerous female. Integument shining, sparsely and faintly pitted, particularly on carapace.

Carapace two-thirds as long again as deep, considerably compressed, and one-fourth of total length of animal; a serrated crest runs from apex of frontal lobe to just beyond middle of length of carapace; this is cut into nine teeth, the anterior five separated from the others by a wider interspace; antennal notch rather

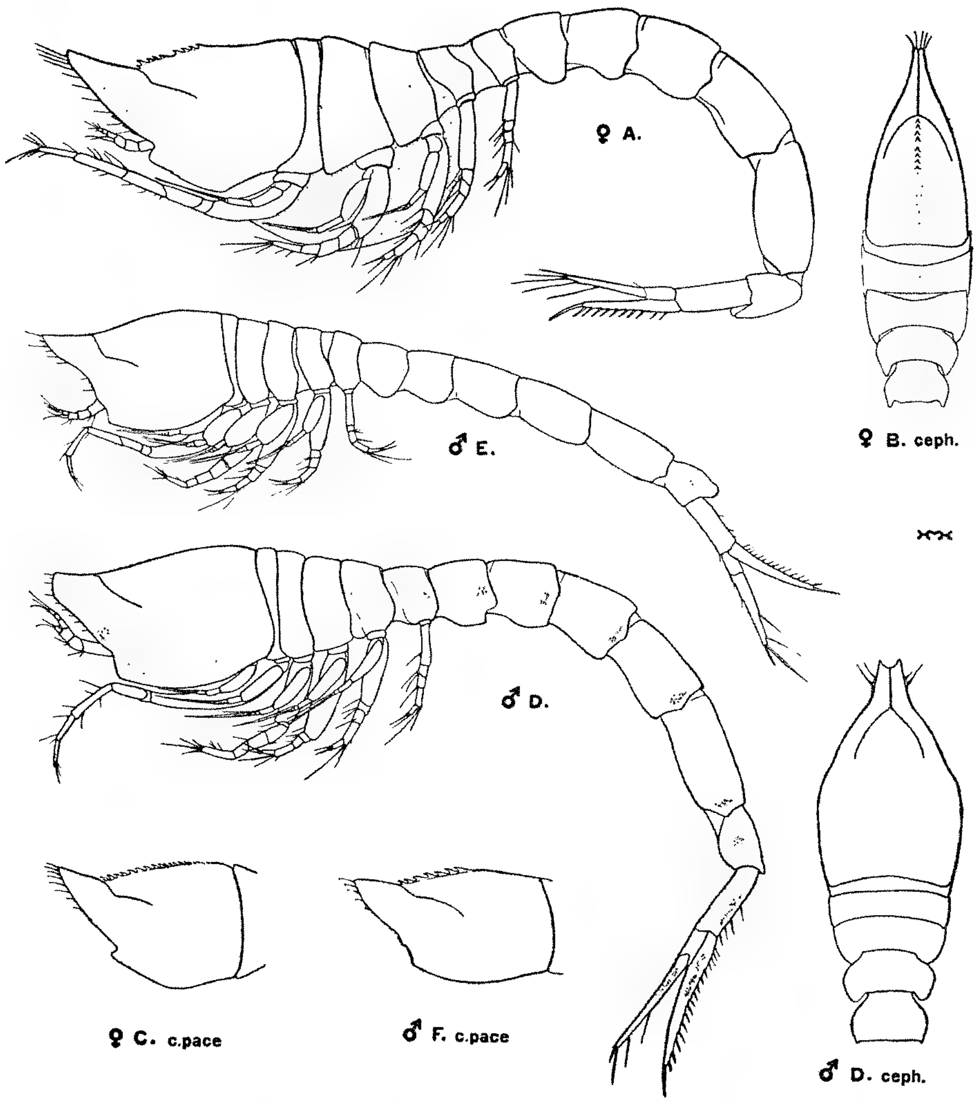

Fig. 3 *Hemileucon levis.* A, lateral view of type female. B, Cephalothorax of ovigerous female. C, Carapace of female showing variation in armature. D, Type male, lateral view and (ceph.) cephalothorax from above. E, lateral view of small adult male. F, Carapace of adult male with serrated crest (all x 32).

deep and angle narrowly rounded; inferior margin immediately posterior to antero-lateral angle feebly serrate. Pseudorostrum long, the lobes meeting for a distance equal to nearly one-third of total length of carapace; its anterior margin is subtruncate, slightly oblique and feebly serrate, while the very oblique lower margin is irregularly toothed.

None of pedigerous somites greatly expanded on sides, but pleural parts of second longer than in any of the others; together they are a little shorter than carapace.

Pleon a little longer than cephalothorax; fifth somite much longer than any of the others and nearly twice the length of telsonic somite, which is as broad as long, rounded posteriorly.

First segment of peduncle of first antenna distinctly longer than second and third together, and second a little longer than third; flagellum three-jointed, its first segment longest and about equal in length to the single-jointed accessory lash.

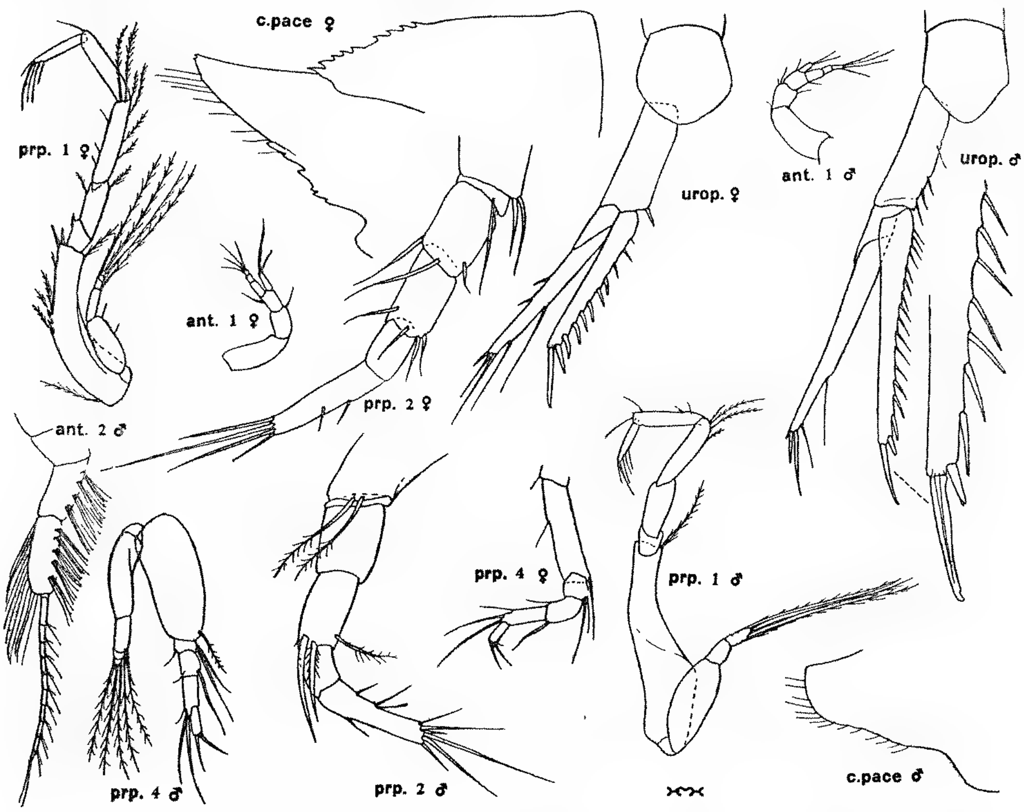

Fig. 4 *Hemileucon levis*, paratypes female and male; c, pace, front of carapace from the side; ant. 1-2, first and second antennae; prp, 1 and 4, first and fourth peraeopods (x 60; distal part of endopod of uropod, x 135); prp, 2, second peraeopod, basis not shown (x 135).

Basis of first peraeopod not much more than half as long as remaining joints together, with plumose seta at outer distal angle, and with spines at inner distal angle; ischium with an inner tooth; carpus a little longer than propodus, which is longer than merus; dactylus about two-thirds as long as propodus, with one of its terminal setae stout.

Second peraeopod with ischium short but distinct; merus subequal in length to carpus; dactylus almost as long as carpus and propodus together, and with longest of terminal setae fully as long as propodus and dactylus together.

Third and fourth peraeopods with basis not or barely longer than rest of limb.

Exopod of uropod one-fifth as long again as endopod and two-thirds as long again as peduncle, which has a single spine near distal end of inner margin;

endopod with no trace of division into two joints and with two or three stout setae on proximal part of inner margin, followed by seven rather stout spines, the last a little stouter than the others and subterminal; the robust terminal spine is more than one-third as long as the ramus; exopod with two long setae on inner edge and three slender and very unequal spines at apex.

The animal is translucent in alcohol, without colour markings. Length 3·5 mm.

Adult male. Carapace rather more than half as long again as deep; seen from above it is somewhat inflated (as wide as deep) in posterior half and the sides are sinuate, tapering rapidly to the front in anterior half; it is one-fourth of total length of animal and has no dorsal serrations (see below). Antennal notch widely open and angle a little obtuse. Pseudorostral lobes subtruncate in front, meeting for a distance equal to almost one-fifth of length of carapace.

Pedigerous somites successively increasing in length, together distinctly shorter than carapace.

Pleon distinctly longer than cephalothorax; telsonic somite longer than wide, quite well produced posteriorly above bases of uropods.

First antenna much as in female. Last joint of peduncle of second antenna not much longer than the preceding; flagellum not or scarcely reaching beyond hinder end of carapace, composed of eleven joints, the first very short, the second the longest.

Basis of first peraeopod relatively long, although shorter than rest of limb, with a plumose seta at external distal angle; remaining joints of same proportions as in female.

Second peraeopod with short, collar-like ischium; carpus with two particularly stout distal spines and a plumose seta.

Third and fourth peraeopods with basis distinctly longer than rest of limb; no outstanding features.

Rami of uropod subequal in length, nearly twice as long as peduncle, which has four slender spines on inner edge; endopod single-jointed, its inner edge with four stout proximal setae, followed by a series of eleven spines, scarcely differing in length, but the last two slightly stouter than the others; there are two more robust spines at apex, the truly terminal one three times as long as the other and one-fourth as long as the ramus.

Colour translucent, with mottling of red pigment at antennal notch and on last pedigerous and pleon somites. Peduncle and rami of uropod with linear red mottlings.

Length 3·25 mm.

Loc.—New South Wales: 5 miles off Port Hacking, 100 metres (July 1943); 4 miles off Eden, 70 metres (Oct. 1943); 4 miles off Port Hacking, 80 metres (type female, May 1944); Ulladulla, 75 metres (type male, June 1944)—all K. Sheard, A. Trawl, on mud or silt; Ulladulla, Brush Island, 45 fath., fine silt on flathead grounds (D. Rochford, A. Trawl, Jan. 1945). Types in South Australian Museum, Reg. No. C. 2549 and 2563.

A male taken with the type male had the red pigmentation as described. The size is variable; one ovigerous female (from 100 metres) is only 2·85 mm. in length (fig. 3, B), while a male with exopods fully developed is 2·7 mm. This last example has the dorsum of the carapace smooth and rounded as in the type, although the pseudorostrum is less truncate anteriorly when viewed from the side (fig. 3, E). A slightly larger male (2·85 mm.), also with fully developed exopods, has the dorsum of the carapace serrate as in the type female, but with the

teeth in a continuous series (fig. 3, F). The carapace armature of the female is variable; usually there is a break in the series (four or five plus four; or three plus four or five), but in one example the dorsum is serrate for practically the whole length (fig. 3, C), although the posterior teeth are insignificant.

Genus Eudorella Norman

Eudorella Stebbing, 1913, 74 (syn.); Hansen, 1920, 21.

Only five of the twenty-two species previously described have been noted for the southern hemisphere. Calman (1907, 33) records *truncatula* (Spence Bate) from the South Island of New Zealand, and Zimmer has named four Antarctic and Subantarctic species, *gracilior, fallax, splendida* and *sordida* (Stebbing, 1913, 77, 80 and 81, ref. and syn.).

Eudorella rochfordi sp. nov.

Ovigerous female. Integument smooth except for faint pitting, which is most distinct on carapace; thin and translucent.

Carapace rather less than one-fifth of total length of animal and as long as the first four pedigerous somites combined; it is compressed (one-third as deep again as wide) and not very much longer than deep. Antero-lateral angle not

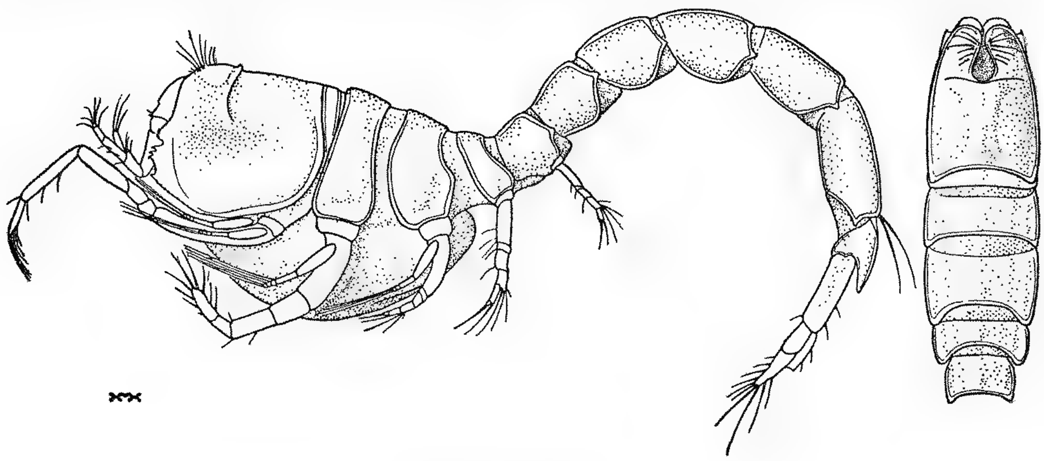

Fig. 5 *Eudorella rochfordi,* type female; lateral view and cephalothorax from above (x 35).

prominent but armed with a tiny tooth, behind which the inferior margin is shallowly serrate for nearly half its length. Anterior margin immediately above antero-lateral tooth slightly emarginate, then with a prominence cut into three (left side) or four (right) teeth, the lower two of which are downbent; a little distance above this again is a second prominence cut into four or five teeth, mostly directed upwards; between the two prominences the sinus is distinct. Upper margins of pseudorostral lobes slightly vaulted as seen from the side, each with a group of prominent setae, the longest equal in length to about one-third depth of carapace.

First pedigerous somite partially covered by second on sides; third somite a little longer on sides than any of the others excepting the fifth.

Pleon longer than cephalothorax; fifth somite three-fourths as long again as telsonic somite and with a pair of long dorsal setae, placed close together at posterior end, and reaching fully to end of telsonic somite; the last-named is well produced above bases of uropods.

First antenna with second segment of peduncle not at all dilated and distinctly more than half as long again as third, which is about as long as the wide first joint; main flagellum three-jointed, the first segment as long as last peduncular joint, and two and one-third times as long as second; third very small; accessory flagellum single-jointed, not much shorter than first segment of the other lash.

Third maxilliped much as in female of *emarginata* but with basis not longer than remaining joints together; carpus one-fourth as long again as propodus, which is equal in length to ischium and merus together, and is fully one-third as long again as dactylus.

First peraeopod slender, the merus reaching to level of anterior margin of carapace; basis two-thirds as long as rest of limb; propodus half as long again as carpus and twice as long as dactylus.

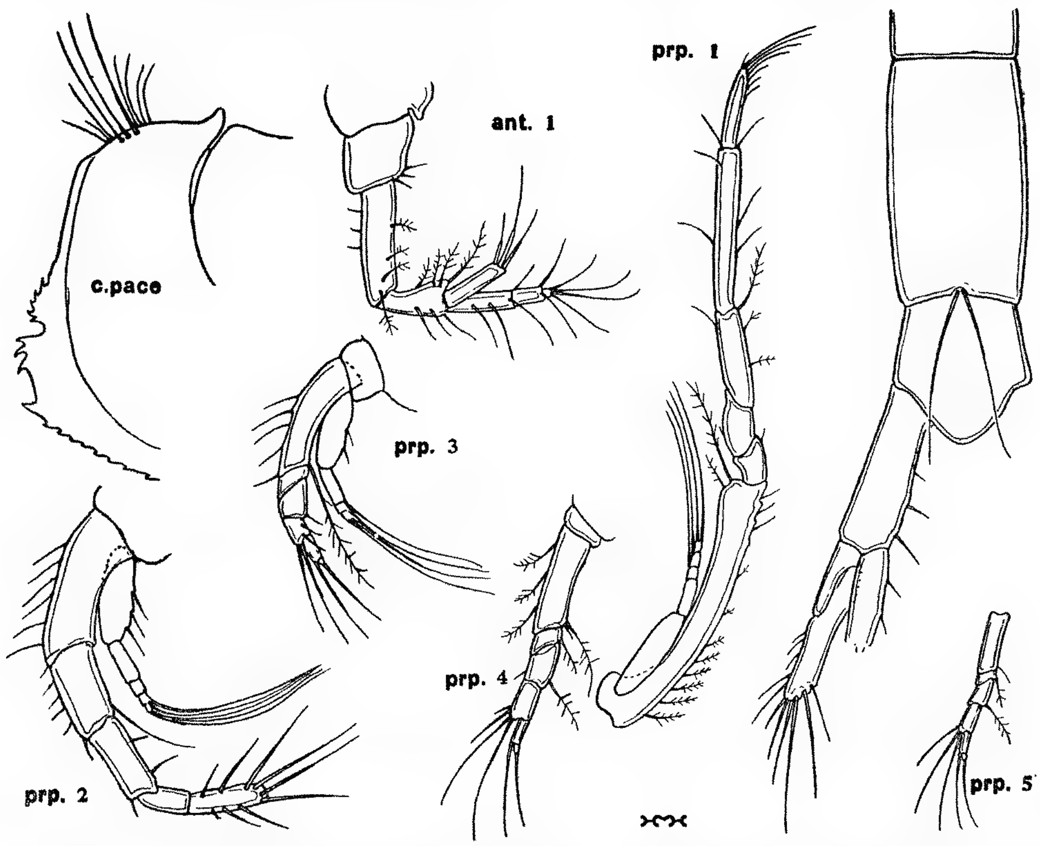

Fig. 6 *Eudorella rochfordi*, type female; c, pace, anterior edge of carapace from the side (x 87); ant. 1, first antenna (x 87); prp, first to fifth peraeopods (x 74); urop, uropod with fifth pleon and telsonic somites (x 74).

Second peraeopod with basis only as long as combined lengths of merus and carpus, which are equal in length; dactylus not quite twice as long as propodus, almost as long as carpus, and with the longest terminal setae nearly as long as propodus plus dactylus.

Basis longer than rest of limb in third peraeopod, equal to this in fourth and shorter than remaining joints together in fifth; third and fourth pairs subequal in length (each a little more than half as long as second leg) and fifth only two-thirds as long as fourth; dactylar seta and longest propodal seta in all at least equal to combined lengths of the three distal joints of the limbs.

Peduncle of uropod little longer than telsonic somite and equal in length to exopod, its inner margin with three short setae; endopod broken.

Length 3·33 mm.

Loc.—New South Wales: Ulladulla, Brush Island, 45 fath., in fine silt on flathead grounds (D. Rochford, A. Trawl, Jan. 1945). Type in South Australian Museum, Reg. No. C. 2761.

A single example was found amongst a mass of Cumacea collected by the Hydrologist of the Fisheries Division, C. S. and I. R., Mr. D. Rochford, after whom the form is named.

This species belongs to the puzzling *truncatula* group (Hansen, 1920, 21). While the anterior margin of the carapace is very like that of *truncatula* (Spence Bate) the general shape of the carapace is more as in *hirsuta* Sars (Sars, 1900, pl. xxix-xxx). It differs from *truncatula* in having the vaulted upper profile of the pseudorostral lobes furnished with longer and more prominent setae, while the pair of dorsal setae at the posterior end of the fifth pleon somite, instead of being insignificant, project over the telsonic somite as in *emarginata* (Kröyer) —Sars, 1900, pl. xxvii. Further, the second joint of the peduncle of the first antenna is relatively longer (little longer than third in female of *truncatula*), the flagella of this appendage are longer and the propodus of the first peraeopod is proportionately more elongate (only one-third as long again as carpus in *truncatula*); the endopod of the uropod also may show some difference.

As previously noted, Calman refers a small species of *Eudorella* from New Zealand to the North Atlantic *truncatula,* remarking at the same time on some slight differences.

Summary

The family Leuconidae is poorly represented off Australian shores, and amongst a considerable amount of Cumacean material collected on the southern and eastern coasts only three species have been found—*Leucon ocularis, Hemileucon levis* and *Eudorella rochfordi* spp. nov. The two first-named are distinctive in the genera they are referred to, but the last resembles closely the North Atlantic *Eudorella truncatula* (Spence Bate).

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ACARINA OF AUSTRALIA AND NEW GUINEA THE FAMILY LEEUWENHOEKIIDAE

BY H. WOMERSLEY, ENTOMOLOGIST, SOUTH AUSTRALIAN MUSEUM
(READ 10 MAY 1945)

Summary

In 1944 (Trans. Roy. Soc. S. Aust., 68, (1), 102) the present writer erected the subfamily Leeuwenhoekiinae for the larval genus *Leewenhoekia* Ouds. 1911, on the discovery of a true stigmal opening situated on each side between coxae I and the gnathosoma, from which tracheal tubes ramify through the body. In this feature the species of *Leewenhoekia* s.l. differ from the other genera of the Trombiculinae.

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THE FAMILY LEEUWENHOEKIIDAE

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[Read 10 May 1945]

In 1944 (Trans. Roy. Soc. S. Aust., **68**, (1), 102) the present writer erected the subfamily Leeuwenhoekiinae for the larval genus *Leeuwenhoekia* Ouds. 1911, on the discovery of a true stigmal opening situated on each side between coxae I and the gnathosoma, from which tracheal tubes ramify through the body. In this feature the species of *Leeuwenhoekia* s.l. differ from the other genera of the Trombiculinae.

I am now convinced that such a fundamental character justifies raising the group to familial rank, and in this paper propose the family Leeuwenhoekiidae. I am more disposed to do this as Ewing recently (1944 Proc. Biol. Soc. Wash., **57**, 101-104) raised the Trombiculinae to Trombiculidae.

In 1944 (*loc. cit.*) it was suggested that the allied genus *Hannemannia* Ouds. might also be found to possess similar true stigmal organs, but as that genus has not yet been found to be represented in Australia, I had not seen any species. Through the kindness of Sq./Ldr. C. D. Radford, however, I have recently been privileged to study a mount of *Hannemannia ochratoma* Radford from a pika from Rassis Hole, Montana, U.S.A., and can now affirm that this genus, which in the larvae is closely related to *Leeuwenhoekia,* also possesses a true stigma on each side between the gnathosoma and coxae I.

In the Journal of Parasitology, 1942, **28**, Ewing subdivided the genus *Leeuwenhoekia* Ouds., retaining *Leeuwenhoekia* s. str. only for the genotype, *verduni* Ouds. 1910. The remaining known species he placed in two new genera *Comatacarus* and *Acomatacarus.*

Leeuwenhoekia s. str. was diagnosed as having the dorsal setae relatively few and arising from tubercles, the postero-lateral scutal setae differing from the others in being distally thickened or clavate, and the chelicerae serrated. The other two genera have more dorsal setae but not set on tubercles, and the postero-lateral scutal setae similar to the others. In *Comatacarus* the chelicerae possess only a single dorsal and a single ventral tooth; in *Acomatacarus* the chelicerae are serrated. In the last genus Ewing placed the Australian species *L. australiensis* Hirst and two other species.

In the same paper Ewing also agreed that the peculiar quill infesting genus *Apolonia* Torres and Braga 1939, as the authors suggested, was closely related to *Leeuwenhoekia.*

Hitherto the above genera only have been known, and these only from the larvae. Recently, however, Major G. M. Kohls of the American Scrub-Typhus Commission, has been successful in rearing fully engorged larvae of two species of *Acomatacarus* to the nymphal stage, while Lt.-Col. C. B. Philip has reared the nymph of a third species. Three species, previously referred to the Microtrombiinae, and known only from the adults, also agree with these nymphs, and are placed here in *Acomatacarus.*

For the readiness with which the above colleagues have entrusted their material to the writer for taxonomic study I tender my grateful appreciation.

Family **Leeuwenhoekiidae** nov.

= *Leeuwenhoekiinae* Womersley 1944, Trans. Roy. Soc. S. Aust., **68**, (1), 102.

Diagnosis of Larvae—Typical Trombidiid larvae, with pseudostigma (urstigma) between coxae I and II, and on each side between gnathosoma and coxae I a true stigmal opening, from the atrium of which tracheal tubes traverse the body. With a single dorsal scute furnished with 2 antero-median, 2 antero-lateral and 2 postero-lateral setae (absent in *Apolonia*), as well as a pair of filamentous sensillae; anteriorly the scutum with or without a median tongue-like process. All tarsi with similar paired claws and median longer claw-like empodium.

Diagnosis of Nymphs—Typical Trombidiid facies, rather elongate, widest across the shoulders and distinctly narrowing behind but without the characteristic medial constriction of the Trombiculidae. Eyes present or absent, if present then 2 + 2, sessile and away from crista. Crista elongate, linear, with sub-posterior sensillary area furnished with two long filamentous sensillae; anteriorly the crista is expanded into a characteristic rounded or arrow-head-shaped nasus carrying two long, normally ciliated setae which are probably homologous with the antero-median scutal setae of the larvae. Palpi rather slender, tibia with strong apical claw, no accessory claw, but several strong spines instead, without pectines. Chelicerae finely serrated on inner edge. Legs long and slender, I and IV longer than body. Dorsal setae varied. Genital organs with two pairs of discs.

Diagnosis of Adults—As in nymphs but of larger size and genitalia with 3 pairs of discs, except in *Neotrombidium* which has only 2 pairs of elongate oval discs.

Within this family would also appear to belong the genus *Neotrombidium* Leonardi 1901, which was included in the subfamily Microtrombidiinae by Sig Thor 1935 and Womersley 1937. It only differs from the other adult genus known, *Acomatacarus*, in that the nasus is more or less rounded and not arrow-head-like.

Key to the Larval Genera of Leeuwenhoekiidae

1 Dorsal scutum without anterior median process. Both AL and PL scutal setae present.
Hannemannia Ouds. 1911
type *hylodeus* Ouds. 1910

Dorsal scutum with an anterior or median tongue-like process. 2

2 PL scutal setae wanting.
Apolonia Torres & Braga 1939
type *tigipioensis* Torr. & Braga 1939

PL scutal setae present. 3

3 PL scutal setae distally thickened and differing from AL. Dorsal setae relatively fewer and arising from tubercles. Chelicerae with a row of blunt teeth.
Leeuwenhoekia Ouds. 1911
s. str. Ewing 1942
type *verduni* Ouds. 1910

PL and AL scutal setae similar and not thickened distally. Dorsal setae more numerous and not on tubercles. 4

4 Chelicerae with only a single dorsal and a single ventral tooth, and not obliquely flattened distally.
Comatacarus Ewing 1942
type *americanus* Ewing 1942

Chelicerae with a row of teeth on upper margin.
Acomatacarus Ewing 1942
type *arizonensis* Ewing 1942

Key to the Known Nymphal and Adult Genera of Leeuwenhoekiidae

1 Anterior nasal expansion of crista arrow-head shaped. Eyes present or absent. Dorsal setae varied. *Acomatacarus* Ewing 1942

Anterior nasal expansion of crista more or less rounded. Eyes present. Dorsal setae trifurcate. *Neotrombidium* Leonardi 1901

Genus Acomatacarus Ewing 1942

Jour. Parasitology 1942, **28,** 490 (Genotype *A. arizonensis* Ewing 1942).

In this genus, as defined by Ewing, will come all the larval species previously described from Australia and New Guinea; *australiensis* Hirst, *southcotti* Wom., *mccullochi* Wom., *adelaideae* Wom., *hirsti* Wom., and *nova-guinea* Wom., as well as the new species, *longipes, athertonensis, barrinensis* and *echidnus,* described herewith.

Of the above species nymphs of both *longipes* and *nova-guinea* have been reared by Major G. M. Kohls, and more recently Lt.-Col. C. B. Philip has reared nymphs from larvae, from Hollandia, Dutch New Guinea, which I have identified as *australiensis* Hirst.

As a result of these rearings the genus *Acomatacarus* and family Leeuwenhoekiidae can be defined as above, and several Australian Trombidiids previously referred to other genera must now be placed in *Acomatacarus.* These species are *Rhyncholophus attolus* Banks 1916, *R. retentus* Banks 1916, both considered (1934) as *Microtrombidium,* and *Dromeothrombium dromus* Wom. 1939, the last being now shown to be really two species.

The taxonomy of at least this genus of the Leeuwenhoekiidae is particularly difficult in the larval stage, such specific characters as exist being found in the slight differences in the number of dorsal setae, and in the Standard Data of the dorsal scutum. From those few species as yet known from the nymphal and adult stages, however, the specific differences are more manifest in the form and dimensions of the dorsal body setae.

Both these features are in contrast to what is found in the Trombiculidae, where better defined specific characters are to be found in the larvae than in the nymphs and adults.

Acomatacarus australiensis (Hirst 1925)

Leeuwenhoekia australiensis Hirst 1925, Trans. Roy. Soc. Trop. Med. and Hyg. *nec* Womersley 1934, Rec. S. Aust. Mus., **5,** (2), 217; Gunther 1939, Proc. Linn. Soc. N.S.W., **64,** (1, 2), 95; Womersley and Heaslip 1943, Trans. Roy. Soc. S. Aust., **67,** (1), 141 (in part); Womersley 1944, Trans. Roy. Soc. S. Aust., **68,** (1), 104.

Fig. 1 A-E, 5 C

Description of Nymph—Propodosoma somewhat triangular; opisthosoma elongate, rounded posteriorly. Colour in life creamy white. Length 0·6 mm., width 0·3 mm. Legs long and slender, I and IV much longer than body, I 975μ, II ?, III ?, IV 1,275μ, II and III missing from specimen; tarsus I elongate and almost parallel-sided, 300μ long by 75μ high, metatarsus I 225μ long. Eyes absent. Crista elongate, linear (*cf.*, fig. 1 A), 216μ long, with a large subposterior sensillary area with 2 fine filamentous sensillae apparently nude and with their bases ca. 40μ apart; anteriorly with a large triangular arrow-head-shaped nasus carrying anteriorly a pair of ciliated setae, probably homologous with the AM setae of the larval scutum. Palpi rather long and slender, as figured; tibia with long apical claw, no accessory claw or pectines, but with 3 or 4 thick spines at base of claw; tarsus elongate, slightly over-reaching tip of claw. Chelicerae with finely serrated inner edge. Dorsal setae hardly of two distinct sizes, but varying

from 25μ to 40μ in length, with very long setules, more numerous and shorter on one side, sparser (only 2-4) on the other where one setule is fully half the length of the whole seta (*cf.*, fig. 1 D, E).

Loc.—A single nymph bred from larvae identified by the writer as *A. australiensis* (Hirst) from Hollandia, Dutch New Guinea, 1944 (C. B. Philip).

Remarks—I am indebted to Lt.-Col. C. B. Philip of the U.S.A. Scrub Typhus Commission for the above specimen, which he succeeded in rearing. He also furnished specimens of the larvae from which the nymphal stage was reached.

Although at times the larvae of this species are common and a source of annoyance to residents of the suburbs of Sydney, a visit paid to the localities in October 1944 by the writer failed to produce either larvae or any of the later stages.

The separation of the nymph from those of other species may be made by the key on p. 110.

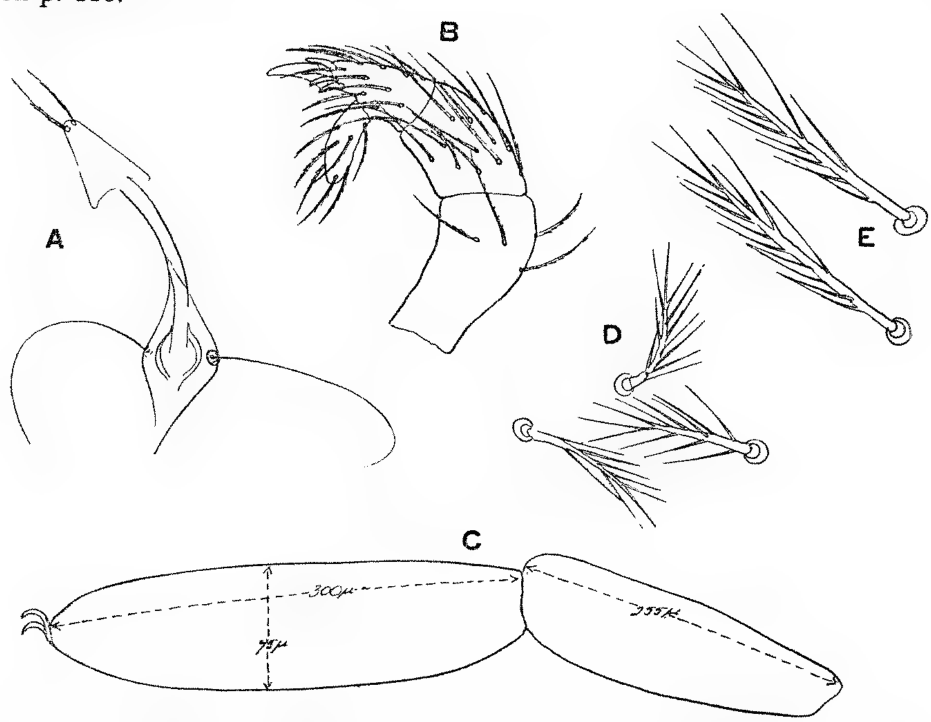

Fig. 1 *Acomatacarus australiensis* (Hirst). Nymph. A, crista; B, palp; C, front tarsus and metatarsus (x 200); D, dorsal setae from propodosoma (x 860); E, dorsal setae from end of opisthosoma (x 860).

ACOMATACARUS NOVA-GUINEA (Wom. 1944)

Leeuwenhoekia nova-guinea Wom. 1944, Trans. Roy. Soc. S. Aust., **68**, (1), 102.

Fig. 2 A-F

Description of Nymph—Propodosoma somewhat triangular; opisthosoma elongate, rounded posteriorly. Colour in life reddish. Length 0·825 mm., width 0·525 mm. Legs long and slender, I and IV much longer than body, I 1,200μ, II 675μ, III 750μ, IV 1,200μ; tarsus I elongate and almost parallel-sided, 310μ long by 82μ high, metatarsus I 218μ long. Eyes absent. Crista elongate, linear (*cf.*, fig. 2B), 254μ long, with a large subposterior sensillary area with two fine, ca. 90μ long, filamentous sensillae with their bases 40μ apart; anteriorly with a large broad arrow-head-shaped area forming a distinct nasus and carrying anteriorly a pair of strong, thickly but shortly ciliated setae, 61μ long, probably homologous with the AM setae of the larval scutum. Palpi long and slender

(*cf.*, fig. 2D), tibia with long apical claw, no accessory claw or pectines, but with 2 or 3 thick spines at base of claw; tarsus rather stumpy, not quite reaching tip of claw. Chelicerae as figured (fig. 2C), with the inner edge finely serrate. Dorsal

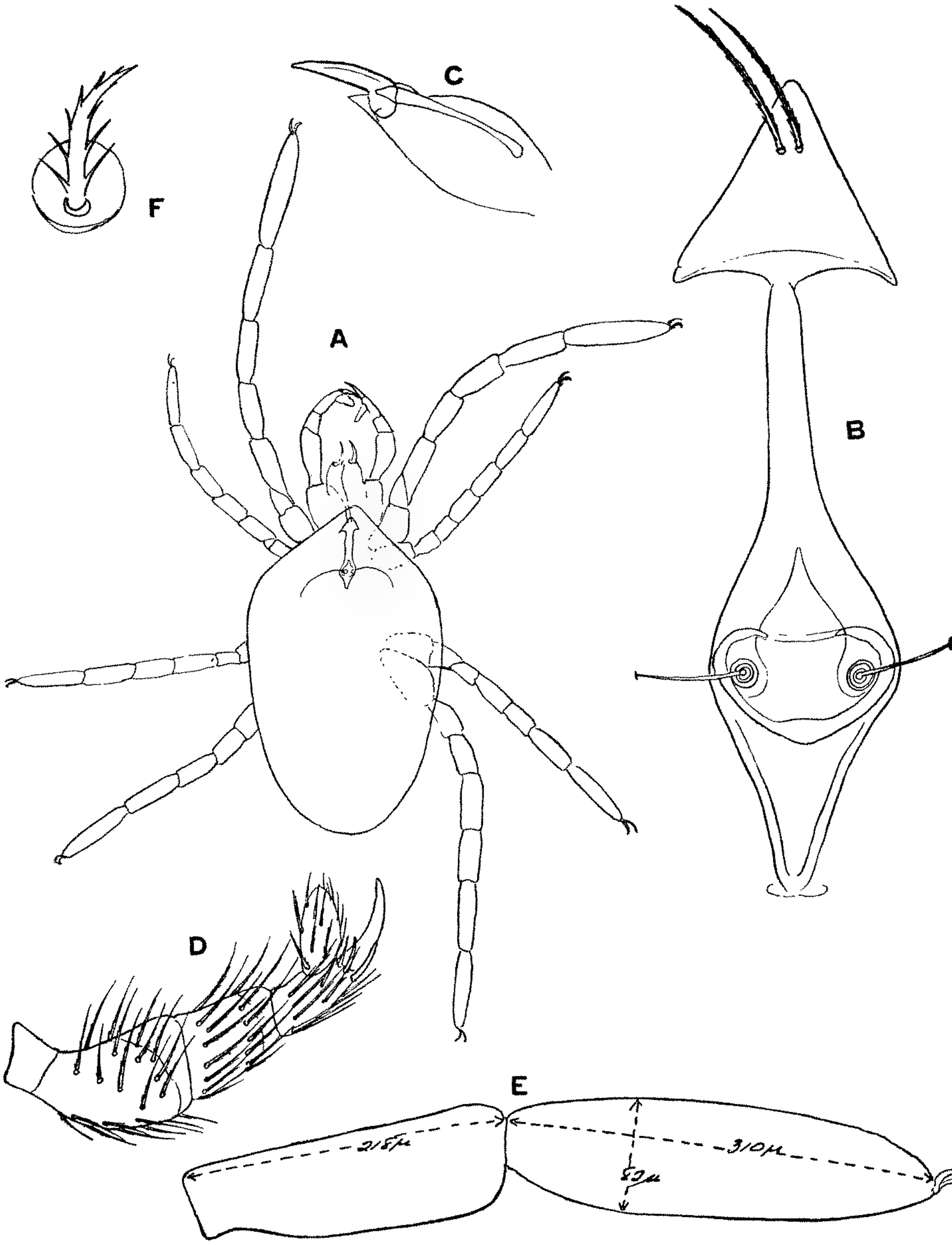

Fig. 2 *Acomatacarus nova-guinea* (Wom.). Nymph. A, entire dorsal view; B, crista (x 375); C, chela; D, palp; E, front tarsus and metatarsus (x 200); F, dorsal seta (x 860).

setae (fig. 2F) uniform in length, 25μ long, slightly curved, thick and tapering with few but basally long setules, and each seta arising from a large rounded platelet.

Loc.—The above is described from two nymphs reared by Maj. G. M. Kohls from engorged larvae identified as *L.* (*Acomatacarus*) *nova-guinea* Wom. from New Guinea, April 1944.

Walch (Goenesk. Tijdschr. v. Ned. Indie, **67**, (6), 922), 1927, recorded some larval *Leeuwenhoekia* from rats in the neighbourhood of Makassar, Celebes as *L. australiensis* Hirst.

From his data and figures the following Standard Data in microns can be derived: PW 86, SB 63, AL 53, PL 67, Sens 71.

In addition the DS number 64 and are ca. 48μ long and PW/SD = 1·36. From these data, the Celebes material agrees more with *A. nova-guinea* than with the Australian species, and should probably be thus assigned.

Acomatacarus longipes n. sp.

Fig. 3 A-F, 4 A-E

Description of Larvae—Fig. 3 A-F. Unfed. Shape subrotund, length 450μ, width 375μ. Dorsal scutum typical of the genus, pentagonal, with the following Standard Data in microns: AW 90, PW 94, SB 32, ASB 40, PSB 29, SD 69, A-P 32, AM 40, AL 65, PL 68, Sens 60 ciliated on distal half. Anterior median scutal process 21μ long by 11μ wide; AM setae 18μ apart at bases and 14μ behind anterior margin. Scutal and dorsal setae shortly ciliated and blunt tipped. Dorsal setae 56-58 in number arranged 2.10.10.8.10.10(12).6. Palpi normal, with bifurcate tibial claw. Chelicerae dorsally serrate as in the genus. Eyes 2 + 2, about 3 diams. from postero-lateral corners of scutum. Legs normal, I 450μ long, II 405μ, III 450μ; coxae III separated from II. Coxae I with 2 setae, II and III with one seta; no setae between coxae I, a pair between coxae III, and thereafter ca. 64 setae, beginning with a row of 12. Claws and tarsi normal. Leg III with a pair of long whip-like setae on tibiae and one on tarsus. True stigma on each side between coxae I and gnathosoma.

Description of Nymph—Fig. 4 A-E. Shape as described for *A. nova-guinea*. Length to 1·125 mm., width to 0·75 mm. across shoulders. Colour in life red. Crista elongate, linear, 405μ long, with rounded subposterior sensillary area with two long filamentous nude sensillae ca. 110μ long and their bases 47μ apart; anterior end of crista expanded into an arrow-head-shaped enlargement with a pair of long ciliated setae anteriorly. Palpi normal, fairly slender, as in *nova-guinea,* with 3-4 strong spines at base of claw. Chelicerae with finely serrate inner edge. Eyes absent. Legs very long and slender, I and IV longer than body, I 2,025μ, II 1,350μ, III 1,470μ, IV 2,175μ; tarsus and metatarsus I long and slender, tarsus I 450μ long by 120μ high, metatarsus 450μ long. Claws normal. Dorsal setae numerous and uniform, decumbent, to 30μ long, rather broad basally and tapering to a point with long ciliations (*cf.* fig. 4 D). On the legs the setae are similar, but are interspersed with some short, curved simple setae (*cf.* fig. 4 E).

Loc.—The type and 1 paratype and 1 unfed and 3 engorged larvae from the the same colony from which the nymphs were reared were sent to me by Maj. G. M. Kohls and were found on *Podargus* sp. from the Dobodura area of New Guinea, 25 July 1940 (G. M. K., 532).

Two other nymphs and several larvae, both unfed and fully engorged from a colony on honey-eaters, from the same locality, 24 May 1944 (G. M. K. 348 and 350) are also this species.

Remarks. Larva—Fig. 3 A-F. Very close to *adelaideae* Wom. 1944 in the number of dorsal setae, but differs therefrom in the wider AW and in the longer AL and PL.

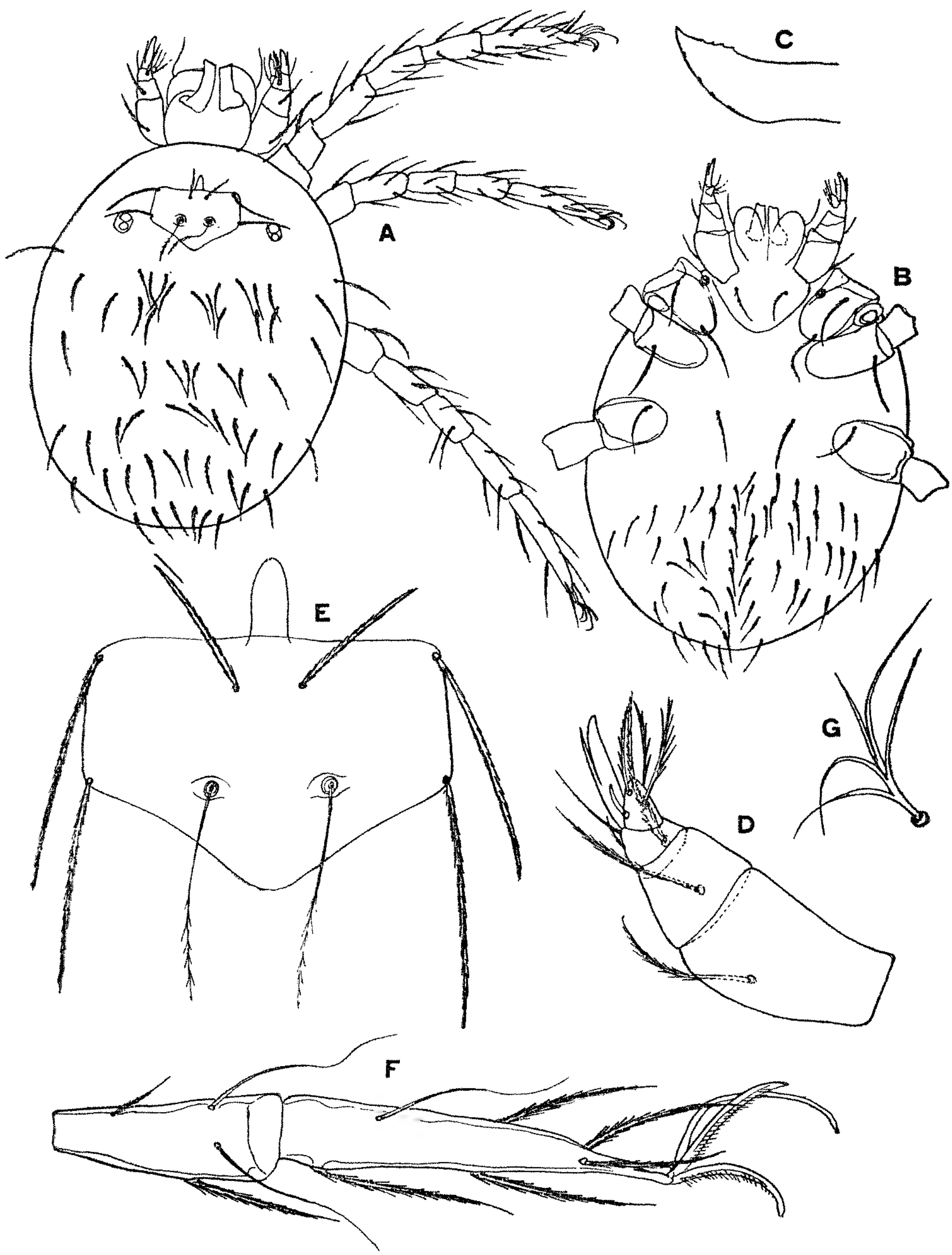

Fig. 3 **Acomatacarus longipes** n. sp. Larva. A, dorsal view; B, venter; C, chela; D, palp; E, dorsal scutum (x 500); F, hind tarsus and metatarsus.

The Standard Data in microns derived from the type, 1 paratype larva, and 5 larvae from the colony from a honey-eater are as follows:—

	Mean	Standard Deviations	Theoretical (1) Range	Observed (1) Range	Coeff. of Variation
AW - -	86·6±1·17	3·11±0·83	77·3– 95·9	83·0– 92·0	3·6
PW - -	96·7±0·85	2·25±0·60	90·0–103·4	93·0–101·0	2·3
SB - -	30·4±0·40	1·05±0·28	27·3– 33·5	29·0– 32·0	3·4
SD - -	72·7±0·98	2·60±0·69	64·9– 80·5	68·0– 77·0	3·6
A-P - -	31·6±0·40	1·05±0·28	28·5– 34·7	29·0– 32·0	3·3
AM - -	43·9±0·55	1·46±0·39	39·5– 48·3	43·0– 47·0	3·3
AL - -	65·7±0·90	2·37±0·63	58·6– 72·8	61·0– 68·0	3·6
PL - -	70·6±0·66	1·76±0·47	65·3– 75·9	68·0– 72·0	2·5
Sens. - -	64·4±0·70	1·84±0·49	58·9– 69·9	62·0– 68·0	2·8

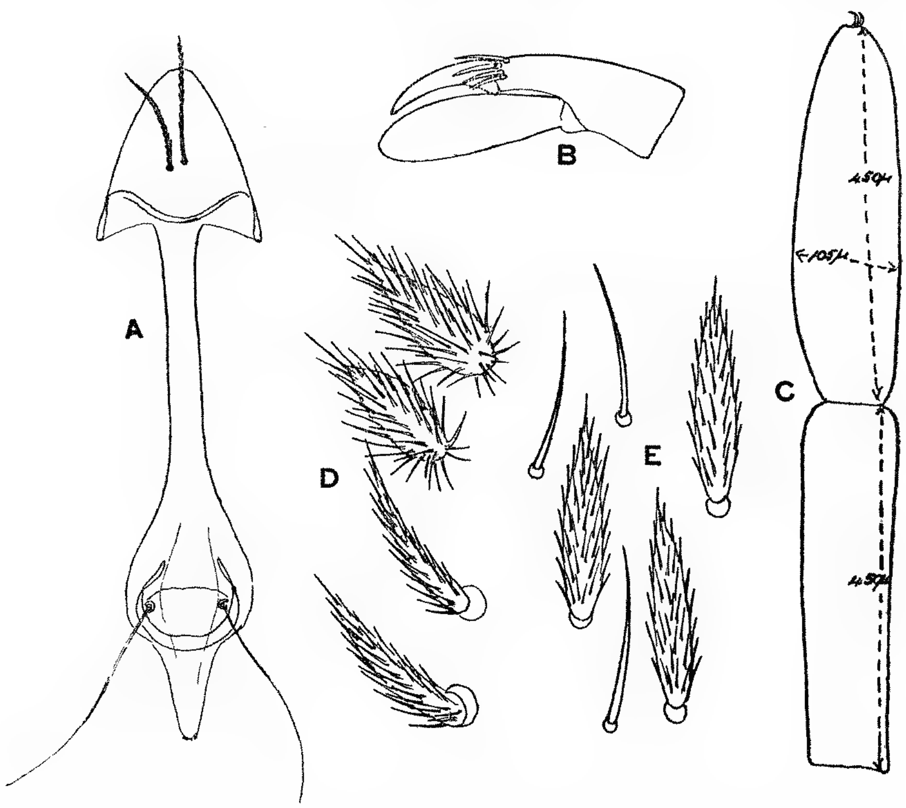

Fig. 4 **Acomatacarus longipes** n. sp. Nymph. A, crista (x 375); B, palp; C, front tarsus and metatarsus (x 125); D, dorsal setae (x 860); E, leg setae (x 860).

Nymph—Differs from other species in the form of the dorsal setae and in the relative dimensions of the front tarsi and metatarsi. In the type, one front metatarsus is slightly shorter than the other, and slightly shorter than the tarsus. In the paratype the front tarsi and metatarsi are the same on both legs. Similarly in the two specimens from honey-eaters the front metatarsi are slightly shorter than the tarsi and in one specimen both segments are much shorter than in the other, which latter agrees with the type. In the second specimen the front tarsi measure 330μ long by 60μ high, and the metatarsi 270μ long, but it agrees perfectly in the dorsal setae.

(1) In mounts of Trombiculidae and Leeuwenhoekiidae excessive compression of the normally convex larval scutum will tend to make the higher values of the Standard Data unreliable, and this should be kept in mind when considering the theoretical and observed ranges.

Acomatacarus athertonensis n. sp.

Fig. 5 A-B

Description—Larvae. Length 270μ, width 205μ. Shape broadly oval. Dorsal scutum typical of the genus, pentagonal, with the following Standard Data in microns for 16 specimens.

	Mean	Standard Deviations	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	66·1±0·35	1·39±0·24	61·9 –70·3	65·0–68·0	2·1
PW - -	77·9±0·42	1·67±0·29	72·9 –82·9	75·0–80·0	2·1
SB - -	24·7±0·16	0·66±0·11	22·75–26·75	23·0–25·0	2·7
SD - -	62·3±0·70	2·82±0·49	53·85–70·75	59·0–68·0	4·5
A-P - -	29·0	No variation recorded			
AM - -	40·6±0·36	1·45±0·25	36·2 –44·0	38·0–43·0	3·6
AL - -	44·1±0·39	1·57±0·28	39·4 –48·8	43·0–47·0	3·6
PL - -	59·9±0·35	1·35±0·24	55·9 –64·0	58·0–61·0	2·2
Sens. - -	50·0	No variation recorded			

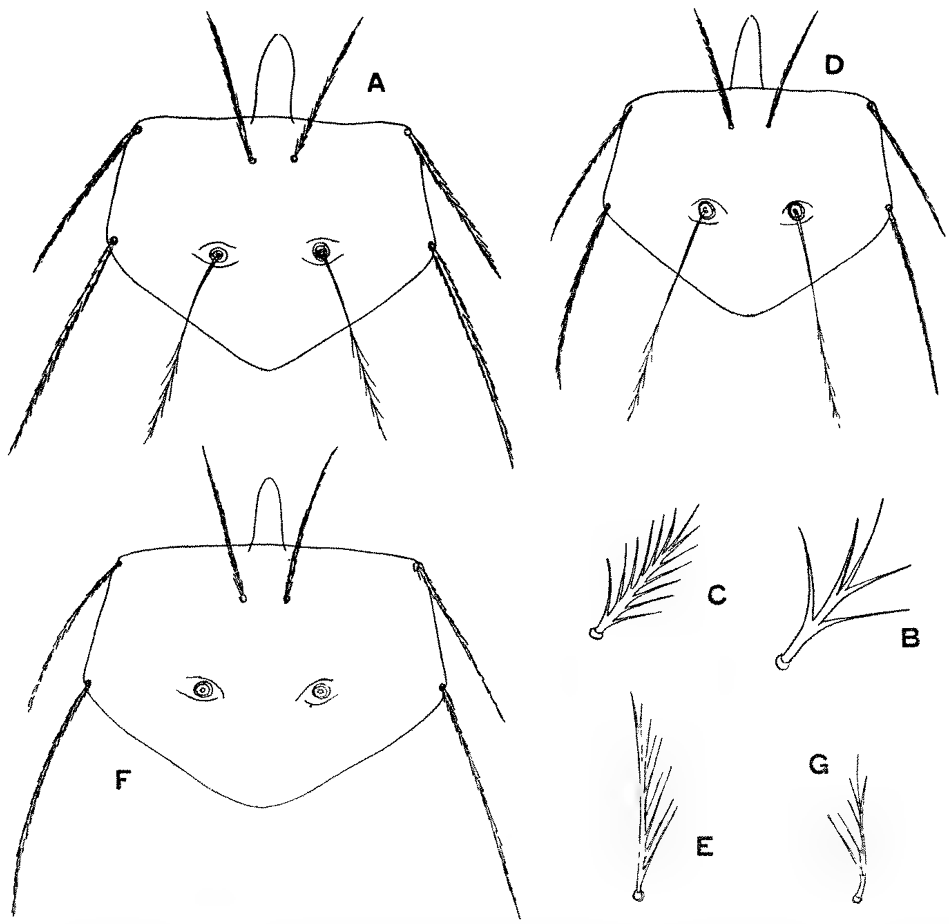

Fig. 5 Larvae A-B: **Acomatacarus athertonensis** n. sp. A, dorsal scutum (x 500), B, gnathosomal seta (x 860); C, *A. australiensis* (Hirst), gnathosomal seta (x 860), D-E, **A. echidnus** n. sp.: D, dorsal scutum (x 500); E, gnathosomal seta (x 860). F-G, **A. barrinensis** n. sp.: F, dorsal scutum (x 500); G, gnathosomal seta (x 860).

Anterior median scutal process 21μ long by 9μ wide. AM with their bases 9μ apart and situated 11μ behind anterior scutal margin. Scutal and dorsal setae strongly ciliated and rather blunt at tip. Eyes 2 + 2, about 1 diam. from postero-

lateral corners of scutum. Dorsal setae difficult to count, but ca. 66 arranged ca. 2.8(9).10.12.10.8.6.2. Ventrally without setae between coxae I, a pair between coxae III, and then ca. 8.10.14.10.6.4 = 52, the latter setae about half the length of the dorsal setae. Coxae I with 2, II and III with one seta. The pair of setae on the base of gnathosoma to 25μ, with 5 long branches. Palpi normal; femur, genu and tibia with long lightly ciliated seta, claw bifurcate, the outer fork reaching half-way to tip of inner fork, tarsus short and stumpy, normal as regards setae. Chelicerae dorsally with 3 or 4 teeth. Legs normal, tibia and tarsus III with a pair and a single whip-like seta as in other species; claws two, with a longer more slender claw-like empodium. Both true and pseudostigmal openings present.

Loc.—From fence posts, etc. Wongabel, Atherton Tableland, Queensland, Oct. 1944 (R. N. McCulloch). Described from 16 syn-types.

Remarks—This species is very close to *australiensis* Hirst in the number and arrangement of the dorsal and ventral setae and cannot be separated therefrom on these features. The Standard Data of the dorsal scutum are consistently lower, the values for AW, PW, SB, SD, A-P, PL and Sens. all being significantly different; the Difference of Means between the population of 16 specimens of *athertonensis* and the 13 specimens of *australiensis* from Chatswood, New South Wales (reported 1944), give the values of d/σ_d as follows:—AW 11·8, PW 11·9, SB 8·0, SD 7·6, A-P 4·2, AM 0·5, AL 2·25, PL 5·4, Sens. 20·8.

Besides these differences the gnathosomal setae are slightly longer, but with only 5 branches, in *athertonensis* (*cf.* fig. 5 B) than in *australiensis* which has many and shorter branches (*cf.* fig. 5 C).

The habits of these larvae are remarkable. Major McCulloch reports that they frequent fence posts and the connecting wires in large numbers, and that they are also very resistent to poisons.

Acomatacarus echidnus n. sp.

Fig. 5 D-E

Description—Larva. Shape elongate oval. Length 218μ, width 162μ. Scutum normal for the genus with the following Standard Data, derived from 7 specimens in microns.

	Mean	Standard Deviations	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	57·7±0·87	2·31±0·62	50·8–64·6	54·0–61·0	4·0
PW - -	69·0±0·38	1·0 ±0·27	66·0–72·0	68·0–70·0	1·45
SB - -	22·1±0·55	1·46±0·39	17·7–26·5	21·0–25·0	6·5
SD - -	55·6±0·83	2·19±0·58	49·0–62·2	54·0–59·0	3·9
A-P - -	25·6±0·53	1·40±0·37	21·4–29·8	25·0–29·0	5·5
AM - -	31·6±0·36	0·80±0·25	29·2–34·0	30·0–32·0	2·5
AL - -	38·0±0·82	2·0 ±0·60	32·0–49·0	36·0–40·0	5·2
PL - -	48·8±0·68	1·53±0·48	44·2–53·4	47·0–50·0	3·2
Sens. - -	54·0	No variation recorded			

Dorsal setae ca. 66 and arranged 2.8.8.8.10.10.10.6.4. 40-45μ long, ciliated and not very tapering; ventral setae, excluding the pair between coxae III ca. 42, arranged 10.8.12.8.4 and ca, 20μ long, rather more slender than dorsal setae. Anterior median scutal process 18μ long by 7μ wide. AM setae 7μ apart at bases and 9μ behind anterior scutal margin. Chelicerae dorsally serrate. Palpi normal as in other species, with bifurcate tibial claw, setae on femur, genu and tibia slender and ciliated. Eyes 2 + 2, about 1 diam. from postero-lateral corners of scutum. Legs I 300μ, II 252μ and III 306μ long, normal; tibia III with 2 long flagellate simple setae, tarsus III with 1 such. Coxae I with 2 setae, II and III with 1 seta. Ventrally gnathosoma with a pair of long, 20μ, setae, as in fig. 5 E.

Loc.—Described from 7 syn-types taken from an echidna, on the Atherton Tableland, Queensland, 11 June 1944 (Lt.-Col. J. M. Bonin).

Remarks—In the ratio of PW/SD = 1·24, this species will come very close to *hirsti* Wom. 1944, but differs greatly in the number of dorsal setae and in the Standard Data, the values of which are significantly lower.

Acomatacarus barrinensis n. sp.

Fig. 5 F-G

Description — Larva. Shape elongate oval. Length 252μ, width 180μ. Scutum normal for the genus with the following Standard Data in microns derived from 6 specimens.

	Mean	Standard Deviations	Theoretical Range	Observed Range	Coeff. of Variation
AW - -	73·0±0·57	1·41±0·32	68·8–77·2	72·0–75·0	1·95
PW - -	87·2±1·01	2·48±0·71	79·7–94·7	84·0–90·0	2·8
SB - -	28·5±0·45	1·12±0·32	25·5–31·8	27·0–30·0	4·0
SD - -	64·7±0·96	2·36±0·68	57·7–71·7	63·0–65·0	3·7
A-P - -	30·2±0·54	1·34±0·39	26·2–34·2	29·0–32·0	4·4
AM - -	40·0	No-variation recorded			
AL - -	44·3±0·77	1·89±0·54	38·7–49·9	43·0–47·0	4·3
PL - -	61·0	No variation recorded			
Sens. - -	Missing in all specimens				

Dorsal setae ca. 64 arranged 2.10.8.6.10.10.8.6.4, from 40-50μ long, ciliated, not much tapering, scapula setae 70μ long; ventral setae, excluding the pair between coxae III, ca. 48, rather shorter and thinner than dorsal setae. Ratio PW/SD = 1·34. Anterior median scutal process 18μ long, by ca. 8μ wide. AM setae situated 14μ behind anterior scutal margin and with their bases 11μ apart. Eyes 2 + 2, about 1 diam. from postero-lateral scutal corner. Palpi and chelae as in preceding species. Legs I 306μ long, II 288μ, III 306μ. Claws and setae normal, tibia III with 2 and tarsus with 1 long flagellate seta. Coxae I with 2, II and III with 1 seta. Gnathosomal setae as figured (fig. 5 G).

Loc.—Described from five syn-types collected free, from Lake Barrine, Queensland, 16 Nov. 1943 (R. V. S.), and a single specimen from man, Atherton Tableland, Queensland, 8 March 1944 (R. V. S.).

Remarks—This species is very close to *athertonensis* in the number of dorsal setae, ca. 64 in each. It differs, however, in the Standard Data, the values for AW, PW and SB being very significantly different.

The following species are only known from the adult and are placed in this family on the characteristic structure of the crista. They are also here referred to the genus *Acomatacarus,* but with a certain amount of reservation until such times as other known larval genera have been reared through to the nymph.

Acomatacarus retentus (Banks)

Rhyncholophus retentus Banks 1916, Trans. Roy. Soc. S. Aust., **40**, 225, pl. xxiii, fig. 2 and 3.

Microtrombidium (*Enemothrombium*) *retentus* Wom. 1934, Rec. S. Aust. Mus., **5**, (2), 193, fig. 34-37.

Calothrombium retentus Wom. 1937, Rec. S. Aust. Mus., **6**, (1), 85.

Fig. 6 A-D

A careful re-examination of the syn-type material of this species in the South Australian Museum now shows clearly that it is congeneric with the nymphs of the previous species. The 3 syn-types are all adults, one at least possibly a male. The re-description is as follows:—

Re-description—Colour in life ? red. Shape apparently much as in previous species. Length 1·-1·5 mm. (after Banks), width ca. 0·8-1·0 mm. Legs I 1,530μ, II 1,125μ, III ?, IV ca. 1,800μ; tarsus I elongate, 360μ long by 110μ high, metatarsus I 330μ long. Crista elongate with a subposterior sensillary area, with paired filamentous, apparently nude, sensillae 150μ long, with their bases 43μ apart; from the sensillary area the crista gradually tapers towards the anterior end, where it expands into an arrow-head-like area forming a nasus and carrying two thickly ciliated setae. Eyes present, 2+2, small, on distinct ocular shields, and lying in a line midway between anterior area and sensillary area of the crista.

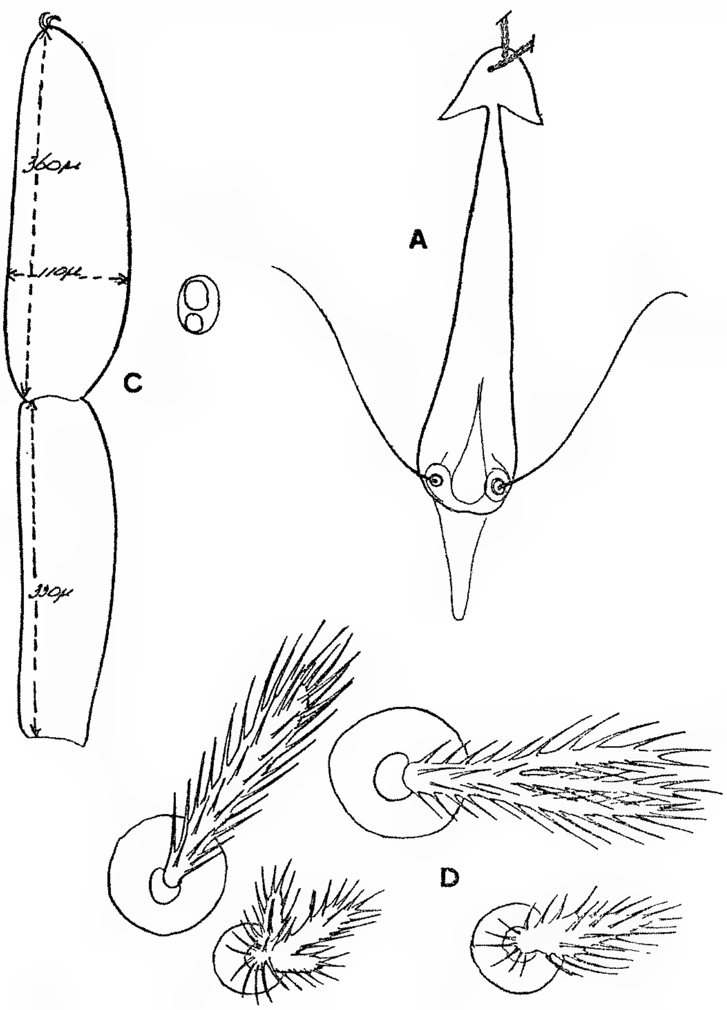

Fig. 6 *Acomatacarus retentus* (Banks). Adult. A, crista and eyes (x 200); B, palp; C, front tarsus and metatarsus (x 125); D, dorsal setae (860).

Palpi rather slender, tibia with strong apical claw, no accessory claw or pectines (the spines shown in Banks' figure are the normal setae and not a pectine), with 4 strong spines at base of claw (*cf.* fig. 6 B). Chelae with finely serrate, inner edge. Dorsal setae of two sizes, both large (to 56μ) and small (to 20μ), thick and strongly setulose, often appearing clavate due to their being bi-, tri- or quadrifurcate (*cf.* fig. 6 D).

Loc.—Only known from the original material from Victoria, and taken at Lal Lal with the ant, *Polyrachis hexacantha,* and at Sea Lake and Ocean Grove with *Iridomyrmex nitidus.*

ACOMATACARUS ATTOLUS (Banks)

Rhyncholophus attolus Banks 1916, Trans. Roy. Soc. S. Aust., **40,** 225, pl. xxiii. fig. 6.

Microtrombidium attolus Wom. 1934, Rec. S.A. Mus., **5,** (2), 189, fig. 24-27.

Microtrombidium (*Dromeothrombium*) *attolus* Wom. 1937, Rec. S.A. Mus., **6,** (1), 86; *ibid,* **7,** (2), 176. Fig. 7 A-D

This species is re-described from the syn-type material.

Re-description—Length 1·2 mm. (after Banks). Eyes according to Banks one on each side, but are not now visible in the preparations of syn-types. If present, then they are probably two small ones on each side, as in *retentus.*

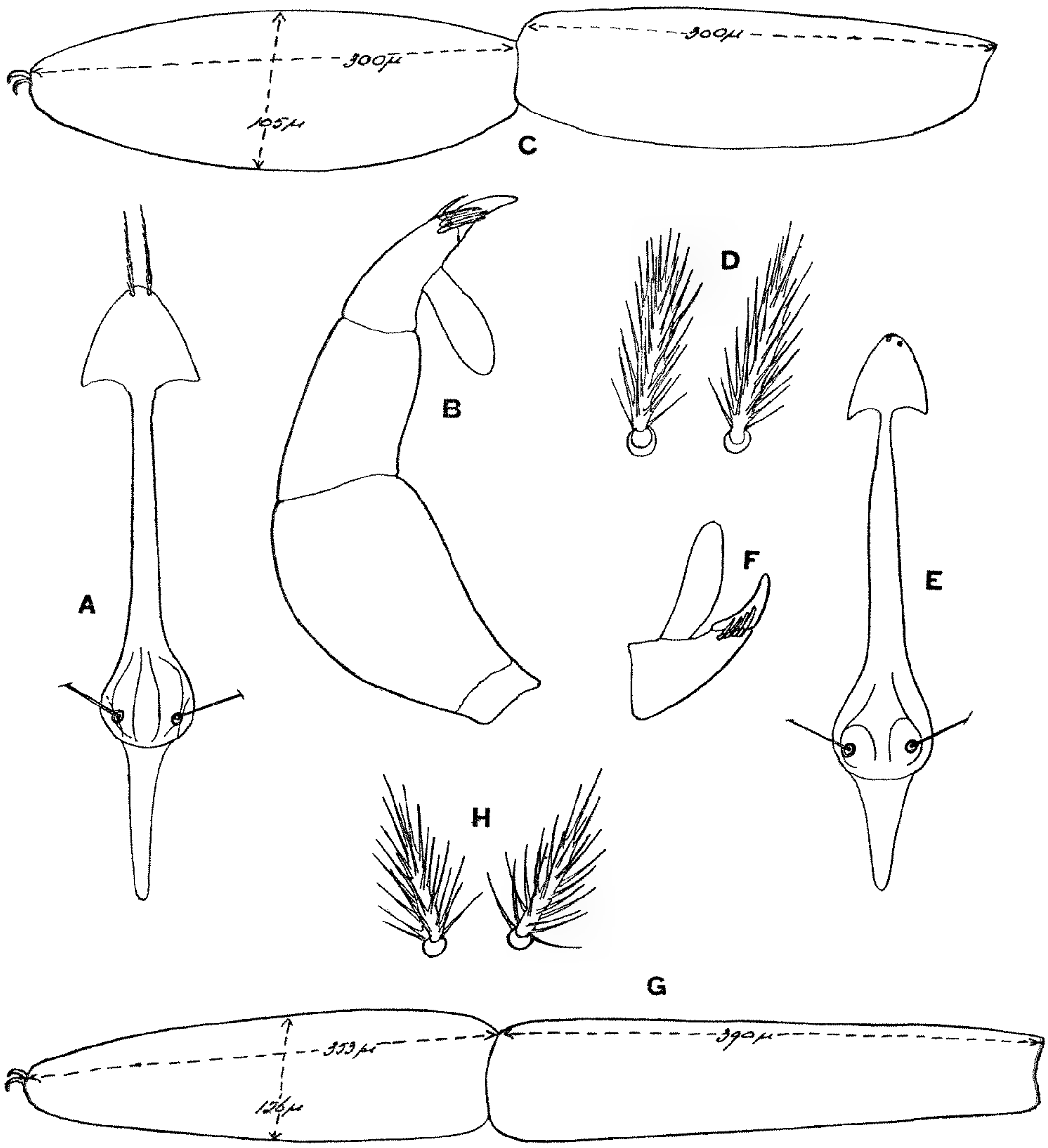

Fig. 7 A-D, *Acomatacarus attolus* (Banks). Adult. A, crista (x 200); B, palp; C, front tarsus and metatarsus (x 200); D, dorsal setae (x 860). E-H, **A. patrius** n.sp.: E, crista (x 200); F, palpal tibia; G, front tarsus and metatarsus (x 200); H, dorsal seta (x 860).

Crista as in fig. 7 A, ca. 300μ long with SB 36μ apart; otherwise as in the genus. Legs I ca. 1,500μ long, II 1,125μ, III 1,035μ, IV 1,980μ; tarsus I almost as long as metatarsus, 300μ long by 105μ high, metatarsus 300μ long. Palpi slender as in fig. 7 B. Dorsal setae uniform, fairly thick and not tapering, with long setules, not furcate as in *retentus,* to 30μ long, tending to be more slender and a little longer laterally, posteriorly and near suture and crista (fig. 7 D).

Loc.—Only known from the original material from Sydney, New South Wales, and taken with the ant *Ponera lutea.*

Acomatacarus patrius n. sp.

= *Dromeothrombium dromus* Wom. 1939, Trans. Roy Soc. S. Aust., **63**, (2), 51 (in part).

Fig. 7 E-H

Description—Adult. Colour in life white. Shape as in other species of the genus. Length 1·7 mm., width 1·35 mm. Legs I 1,770μ, II 1,125μ, III 1,275μ, IV 1,900μ; tarsus I elongate, distinctly shorter than metatarsus, 353μ long by

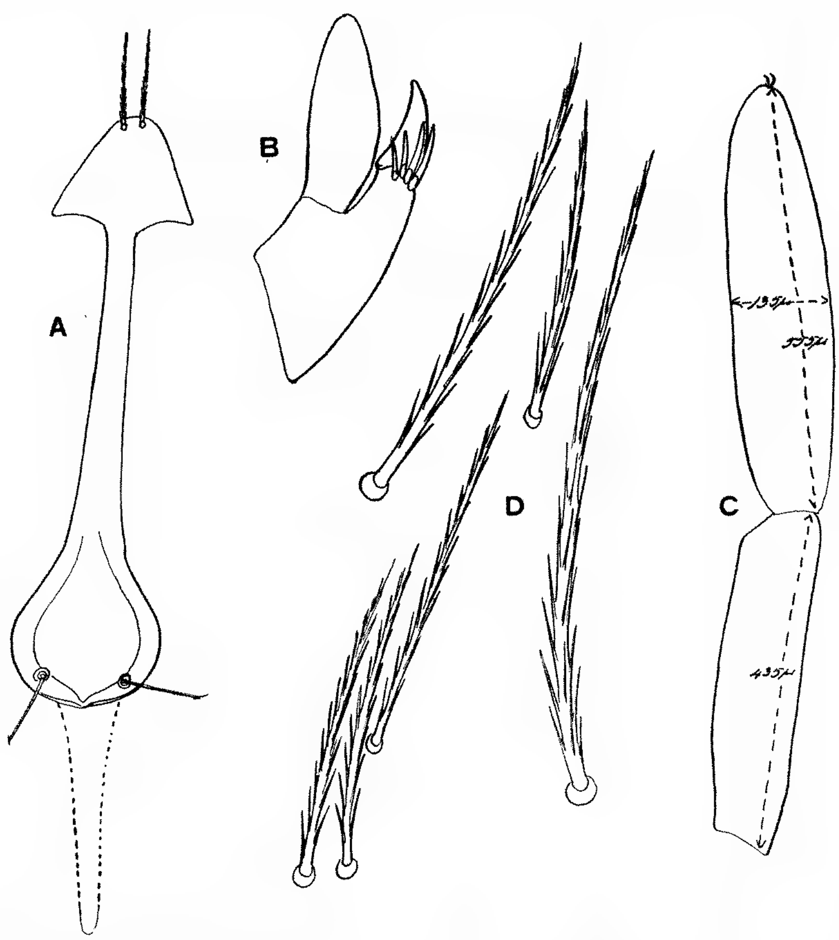

Fig. 8 *Acomatacarus dromus* (Wom.). Adult. A, crista (x 200); B, palpal tibia; C, front tarsus and metatarsus (x 125); D, dorsal setae (x 860).

126μ high and gradually narrowing apically, metatarsus 390μ long. Crista linear, 340μ long, with subposterior sensillary area, with two long filamentous sensillae, their bases 43μ apart; anterior end expanded into a broad arrow-head-like area with the usual two ciliated setae apically. Chelae with finely serrate inner edge.

Palpi elongate, tibia with strong apical claw and 4 straight stout spines at base of claw; tarsus elongate, over-reaching tip of claw. Eyes absent. Dorsal setae uniform, to 20μ, tapering posteriorly and near suture and crista.

Loc.—Type. One specimen from under a stone, Murray Bridge, S. Aust., in mallee country, 25 May 1938 (R. V. S.). Two other adults associated with ants, Burra, S. Aust., 4 Aug. 1940 (J. S. W.).

Remarks—This species is very close to *attolus* Banks, and my material has been so labelled for some time. It differs, however, in the ratio of length of front tarsus to metatarsus and in the form of the dorsal setae.

Acomatacarus dromus (Wom. 1939)

Dromeothrombium dromus Wom. 1939, Trans. Roy. Soc. S. Aust., **63**, (2), 151, E-G (in part).

Fig. 8 A-D

Re-description—Adult. Length 2·4 mm., width 1·3 mm. Colour in life white. Legs I and IV very long, IV much longer than body, I 2,400μ (not 3·32 mm. as reported in 1939 in error), II 1,000μ, III 1,800μ, IV 2,700μ, tarsus I elongate 555μ long by 135μ high, metatarsus 435μ long. Eyes absent. Crista as in fig. 8 A, 430μ long with long, filamentous sensillae with bases 54μ apart on a subposterior sensillary area; anterior end expanded to an arrow-head-like shape, with 2 ciliated setae. Chelae with serrated inner edge. Palpi slender, tibia as in fig. 8 B with 4 spines at the base of claw, tarsus stout and over-reaching tip of claw. Dorsal setae long, slender, tapering with rather short adpressed setules, of two lengths 40-50μ and to 90μ (fig. 8 D).

Loc.—The type and 4 paratypes from Long Gully, S. Aust., 18 Aug. 1938, associated with ants (H. W.).

Remarks—The previous description was drawn up from a complex of species and should be disregarded. This species is abundantly distinct in the dorsal setae.

Key to the Nymphs and Adults of *Acomatacarus*

1 Eyes present, two or ? one on each side. — 2
Eyes absent. — 3

2 Dorsal setae of two sizes, to 20μ and to 56μ, thick with long outstanding setules, often bi-, tri- or quadrifurcate and appearing clavate. Eyes 2+2, small, on ocular shields. — *A. retentus* (Banks 1916)
Dorsal setae uniform, to 30μ, thick and not tapering distally, with fairly long setules. Front tarsus and metatarsus equal in length. Eyes ? 1+1. — *A. attolus* (Banks 1916)

3 Dorsal setae of two lengths, to 45-50μ and to 90μ, long and slender, tapering, with rather short adpressed setules. Front tarsus longer than metatarsus. — *A. dromus* (Wom. 1939, in part)
Dorsal setae more or less uniform, much shorter. — 4

4 Dorsal setae on small platelets, thick, curved, tapering with few setules. Front tarsus longer than metatarsus. — *A. nova-guinea* (Wom. 1944)
Dorsal setae not on platelets. — 5

5 Front tarsus shorter than metatarsus. Dorsal setae slender, tapering, with long setules, to 20μ long (*cf.* fig. 7 H). — **A. patrius** n. sp.
Front tarsus and metatarsus equal. Dorsal setae to 30μ long, bushy and decumbent with finer ciliations (*cf.* fig. 4 D). — **A. longipes** n. sp.
Front tarsus longer than metatarsus. Dorsal setae 25-40μ long, with very long outstanding setules (cf. fig. 1 D). — *A. australiensis* (Hirst 1925)

KEY TO THE AUSTRALIAN AND NEW GUINEA LARVAL SPECIES OF *Acomatacarus* Ewing

1 Tibiae and tarsi of leg III with some long simple whip-like setae. 2

No such long whip-like setae on tibiae and tarsi of leg III. Scutum small and relatively shallow PW/SD = 1·74. AW 62·15±4·45, PW 82·4±5·3, SB 28·6±3·0, SD 49·1±4·0, A-P 27·6±3·9, AM 20·9±1·1, AL 29·9±3·3, PL 40·8±4·0, Sens. 64·3±4·4. DS relatively short, straight and blunt at apex, 42 in number. *A. southcotti* (Wom. 1944)

2 Scutum relatively shallow, PW/SD greater than 1·3. 3

Scutum relatively deeper, PW/SD smaller than 1·3. 7

3 DS between 50 and 60 in number. 4

DS between 60 and 80 in number. 5

4 DS 52-54. PW/SD = 1·335, AW 76·4±5·9, PW 92·4±3·6, SB 28·8±4·4, SD 69·2±1·2, A-P 32·8±1·2, AM 41·2±4·4, AL 37·8±2·9, PL 59·8±7·7 Sens. 63·0±5·2. *A. adelaideae* (Wom. 1944)

DS 56-58. PW/SD 1·33, AW 86·6±9·3, PW 96·7±6·7, SB 30·4±3·1, SD 72·7±7·8, A-P 31·6±3·1, AM 43·9±4·3, AL 65·7±7·1, PL 70·6±5·3, Sens. 64·4±5·5. **A. longipes** n.sp.

5 DS 76. PW/SD = 1·32. AW 77·3±14·2, PW 93·4±14·3, SB 30·2±6·1, SD 70·8±10·5, A-P 31·9±5·3, AM 44·9±9·8, AL 49·0±9·6, PL 63·6±8·2, Sens. 64·0±8·3. *A. australiensis* (Hirst 1925)

DS 62-64. 6

6 DS 62. PW/SD = 1·32. AW 85·7±14·0, PW 98·4±12·3, SB 27·9±6·8, SD 73·0±15·6, A-P 34·2±10·4, AM 41·5±8·9, AL 62·1±17·5, PL 72·8±7·7, Sens. 58·7±12·6. *A. nova-guinea* (Wom. 1944)

DS 64. PW/SD = 1·34. AW 73·0±4·2, PW 87·2±7·4, SB 28·5±3·3, SD 64·7±7·0, A-P 30·2±4·0, AM 40·0, AL 44·3±5·7, PL 61·0, Sens. ?. **A. barrinensis** n. sp.

7 PW/SD 1·194, DS ca. 70. AW 64·0±5·2, PW 81·0±6·0, SB 25·0, SD 71·0±8·5, A-P 32·5±2·6, AM 36·5±2·6, AL 38·0±6·0, PL 54·0, Sens. 44·3±5·7. *A. mccullochi* (Wom.)

PW/SD ca. 1·24 — 1·25. 8

8 DS ca. 82 in number. PW/SD 1·25. AW 79·0, PW 97·0, SB 29·0, SD 77·5, A-P 36·0, AM 43·0, AL 43·0, PL 54·0, Sens. 72·0. *A. hirsti* (Wom. 1944)

DS ca. 66. 9

9 PW/SD = 1·24. AW 57·7±6·9, PW 69·0±3·0, SB 22·1±4·3, SD 55·6±6·6, A-P 25·6±4·2, AM 31·6±2·4, AL 38·0±6·0, PL 48·8±4·6, Sens. 54·0. **A. echidnus** n. sp.

PW/SD = 1·25. AW 66·1±4·2, PW 77·9±5·0, SB 24·7±1·9, SD 62·3±8·4, A-P 29·0, AM 40·6±4·3, AL 44·1±4·7, PL 59·9±4·0, Sens. 50·0. **A. athertonensis** n. sp.

In this key the theoretical range as expressed by Mean ± 3σ is given.

Genus NEOTROMBIDIUM Leon. 1901

Leonardi, 1901 Zool. Anz., **25**, 18; Berlese 1912, Redia, **8**, (1), 49.

Neotrombidium was first erected by Leonardi as a subgenus of *Trombidium* on the supposed absence of the crista and on the presence of a single eye on each side. The type was *Trombidium (Neotrombidium) furcigerum* Leon. from South America.

Berlese in his Monograph, 1912, showed that Leonardi was in error, in that in *furcigerum* a crista and two eyes on each side were present. Berlese raised *Neotrombidium* to generic rank on the following diagnosis:—"Body elongate, abdomen with well developed shoulders. Cephalothorax small, elongate, conical, densely setose. Crista linear, with a posterior rhombic sensillary area. Nasus present. Eyes sessile, difficult to see. Palpi small, with a series of subapical

spines on the fourth segment; tarsus small, elongate, conical. Legs small and slender, shorter than body. Dorsal setae peculiar, trifurcate, fork with short peduncle and rami long-pointed, sub-barbate. Setae of legs simple, spiniform and nude."

Besides the type species Berlese also described *T.* (*Neotrombidium*) *ophtalmicum* from South America. In 1928 Hirst (Ann. Mag. Nat. Hist., (10), 1, 563-571) described *Neotrombidium barringunense* from Barringun, New South Wales, and in 1936 I recorded it from South Australia.

In 1935 in his revision of the subfamilies of the Trombidiidae Sig Thor included *Neotrombidium* in the Microtrombidiinae. It is now evident, however, that in the form of the crista with the anterior end expanded into a more or less round or conical nasus carrying two setae, the genus is closely allied to the nymphs and adults now known to belong to the genus *Acomatacarus* of the Leeuwenhoekiidae.

The Australian species is herewith re-described and details figured.

NEOTROMBIDIUM BARRINGUNENSE Hirst 1928

Hirst 1928, Ann. Mag. N. Hist., (10), **1**, 561-671; Womersley 1934, Rec. S. Aust. Mus., **5**, (2), 185; *idem* 1936, J. Linn. Soc. Zool., **40**, 107.

Fig. 9 A-E

Re-description of Type—Adult. Elongate, broadest across shoulders, then narrowed and parallel-sided to the apex which is rounded, propodosoma small and

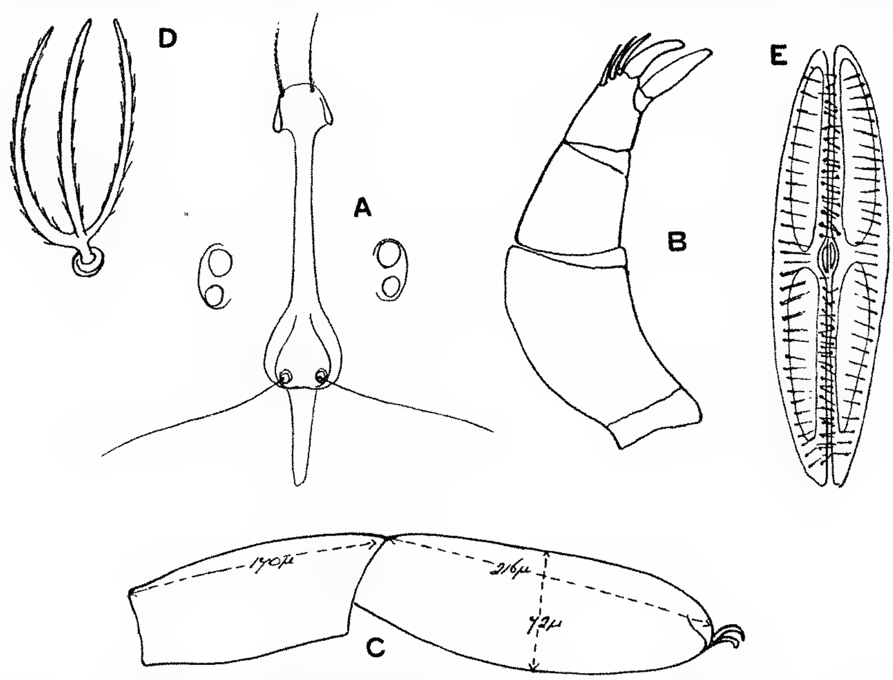

Fig. 9 *Neotrombidium barringunense* Hirst. Adult. A, crista and eyes (x 200); B, palp, C, front tarsus and metatarsus (x 200); D, dorsal seta (x 860); E, genital opening of adult egg-bearing female.

conical-triangular. Colour in life red. Length 1·8 mm., width ·9 mm. Crista linear, 240μ long, with anterior end enlarged to form a more or less rounded nasus with two long setae; with subposterior sensillary area with two long filamentous sensillae with bases 18μ apart. Eyes 2 + 2, on distinct shields, in

advance of sensillary area, and about 2 diams. therefrom, the posterior eye the smaller. Chelicerae sickle-shaped, inner edge only indistinctly and finely serrate. Palpi small and rather slender, tibia with strong curved apical claw, no accessory claw or pectines, but with 2 or 3 strong spines at base of claw; tarsus elongate and over-reaching tip of claw. Legs all shorter than body, I 930μ long, II 570μ, III 660μ, IV 820μ; tarsus I elongate, 216μ long by 72μ high, metatarsus I 170μ long. Dorsal setae uniform to 35μ long, trifurcate, with very short peduncle, the forks shortly and rather indistinctly barbed or ciliated. Leg setae simple. Genital opening very elongate, 280μ with only two pairs of discs, which themselves are elongate (*cf.* fig. 9 E).

Loc.—New South Wales: Barringun, June 1927 (S. Hirst), (type locality); also under eucalypt bark, Bathurst, 31 May 1934 (S. L. A.). South Australia: Menindie, 2 July 1928 (S. Hirst); Long Gully, 12 May 1934 (H. W); Belair, Jan. 1935 (H. W.); under bark, Monarto South, April 1943 (H. W.), in numbers; Robe, by sweeping, July 1943 (H. W.). Queensland; Biloela, Feb. 1943 (Horn.).

Remarks—All these specimens have only two pairs of characteristically elongate oval genital discs and might therefore have been assumed to be only in the nymphal stage, as is the case in most of the Trombidiids. One of the specimens, however, is an adult female, carrying a number of eggs. Two pairs only of genital discs in the adult is therefore not only characteristic of this species, but probably also of the genus. The genital opening also is extraordinarily elongate and situated between the second coxal groups.

Summary

In 1944 (Trans. Roy. Soc. S. Aust., **68**, (1), 102) the subfamily Leeuwenhoekiinae was erected for the genus *Leeuwenhoekia* Ouds., on the presence in the larvae of a pair of true stigmata with tracheae, situated one on each side between the gnathosoma and coxae I. Except possibly in the allied genus *Hannemannia* Ouds. these true stigmata were absent from all other genera of the Trombiculinae, but are now shown to be present in that genus.

As the nymphs of the three larval species of *Leeuwenhoekia, australiensis* Hirst, *nova-guinea* Wom. and *longipes* n. sp. have now been reared, it is shown that these also differ from the nymphs of other genera of Trombiculinae. The nymphs are of an entirely different body shape and lack the characteristic median constriction typical of the Trombiculids. The crista is distinct in having an expanded arrow-head-like anterior nasus, furnished with a pair of setae homologous with the antero-median setae of the larval scutum.

In addition to these nymphs, four species of adults, one new, the others previously placed in genera of the Microtrombidiinae are, on the shape and form of the crista, shown to be related.

On these characters therefore the Leeuwenhoekiinae is raised to Leeuwenhoekiidae.

Ewing's (1944) separation of *Leeuwenhoekia* Ouds. into three genera is accepted and the Australian and New Guinea species now placed in *Acomatacarus* Ewing.

Ten larval species, of which three are known as nymphs and four adult species are recognised.

The genus *Neotrombidium* Leonardi 1901 with the Australian species *N. barringunense* Hirst, with a similar form of crista is included in the Leeuwenhoekiidae. It differs from the only other nymphal and adult genus known, *Acomatacarus,* in having two instead of three pairs of genital discs in the adult, and these very elongate.

SOME PARASITIC NEMATODES FROM SOUTH AUSTRALIAN MARINE FISH

BY T. HARVEY JOHNSTON AND PATRICIA M. MAWSON (READ 10 MAY 1945)

Summary

The fish hosts of most of the parasites recorded in this paper formed part of collections made on our behalf by Messrs. H. M. Cooper, E. J. Hanka, and S. Hurcombe, the material having been obtained from St. Vincent Gulf and Kangaroo Island. We desire to express our thanks to these collaborators, and our indebtedness to the Commonwealth Research Grant to the University of Adelaide. Types of the new species will be deposited in the South Australian Museum, Adelaide.

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List of fish hosts and their parasites referred to in this paper:—

CARANX GEORGIANUS C. & V. *Stomachus marinus* (L.), larva, American River, Kangaroo Island.

PAGROSOMUS AURATUS Forster. *Stomachus marinus* (L.), larva, Glenelg and Cape Jervis; *Cucullanellus sheardi* Jnstn. and Mawson, Glenelg; *Echinocephalus uncinatus* Molin, larva, Glenelg.

LATRIDOPSIS FORSTERI Casteln. *Cucullanellus sheardi* J. & M., Kangaroo Island.

DACTYLOPHORA NIGRICANS Richardson. *Cucullanellus sheardi* J. and M., Backstairs Passage and Rapid Bay.

PSEUDOLABRUS PSITTACULUS Richardson. *Echinocephalus uncinatus* Molin, larva, Port Noarlunga.

SILLAGINODES PUNCTATUS C. & V. *Echinocephalus uncinatus* Molin, larva, Glenelg.

PLATYCEPHALUS BASSENSIS C. & V. *Ascarophis cooperi* n. sp., Rapid Bay.

PLATYCEPHALUS FUSCUS C. & V. *Echinocephalus uncinatus* Molin, larva, Glenelg.

CNIDOGLANIS MEGASTOMA Richardson. *Cucullanellus cnidoglanis* n. sp., Port Willunga.

APTYCHOTREMA BANKSII M. & H. *Proleptus trygonorrhinae* J. & M., Rapid Bay.

The South Australian shovel-nosed ray was identified by Waite (1921, 27; 1923, 47) as *Rhinobatus philippi* Müll. & Henle, syn. *R. banksii* M. & H. McCulloch (1919, 225; 1922, 10; 1934, 10) listed the species from New South Wales as *R. banksii*. Garman in 1913 used the name *R. philippi*, which was not quoted by McCulloch or by Whitley (1934). Norman (1926, 979) allocated *R. banksii* and *R. bougainvillii* M. & H. to *Aptychotrema* and reported that both occurred in New South Wales and were frequently confused. He listed *R. philippi* of Garman and of Waite as a synonym of *A. banksii*. McCulloch's check-list (1929, 22) contains the names *A. bougainvillii* and *A. banksii*, the range of the latter including all Australian States. Whitley (1934) listed the former as the Port Jackson species, and mentioned the chief differences between it and *A. banksii*. In view of the foregoing, we have used the latter name for the southern shovel-nosed ray.

STOMACHUS MARINUS (Linn.)

We have already recorded the occurrence of this widely distributed larva in several species of Australian fish. We reported it as *Capsularia marina* (1943, 22-32), but have recently (1945) indicated that *Capsularia* is a synonym of *Stomachus*. We now record as additional hosts, *Caranx georgianus* from American River, and *Pagrosomus auratus* from Glenelg and Cape Jervis.

Ascarophis cooperi n. sp.

(Fig. 1-3)

Four males and one female were taken from *Platycephalus bassensis* from Rapid Bay. Male, 7-8 mm. long; female, 12 mm.

The two lateral labial processes at the anterior end are small, but distinct. Vestibule ·11-·13 mm. long, 5μ wide. Ratio of width of body at level of posterior

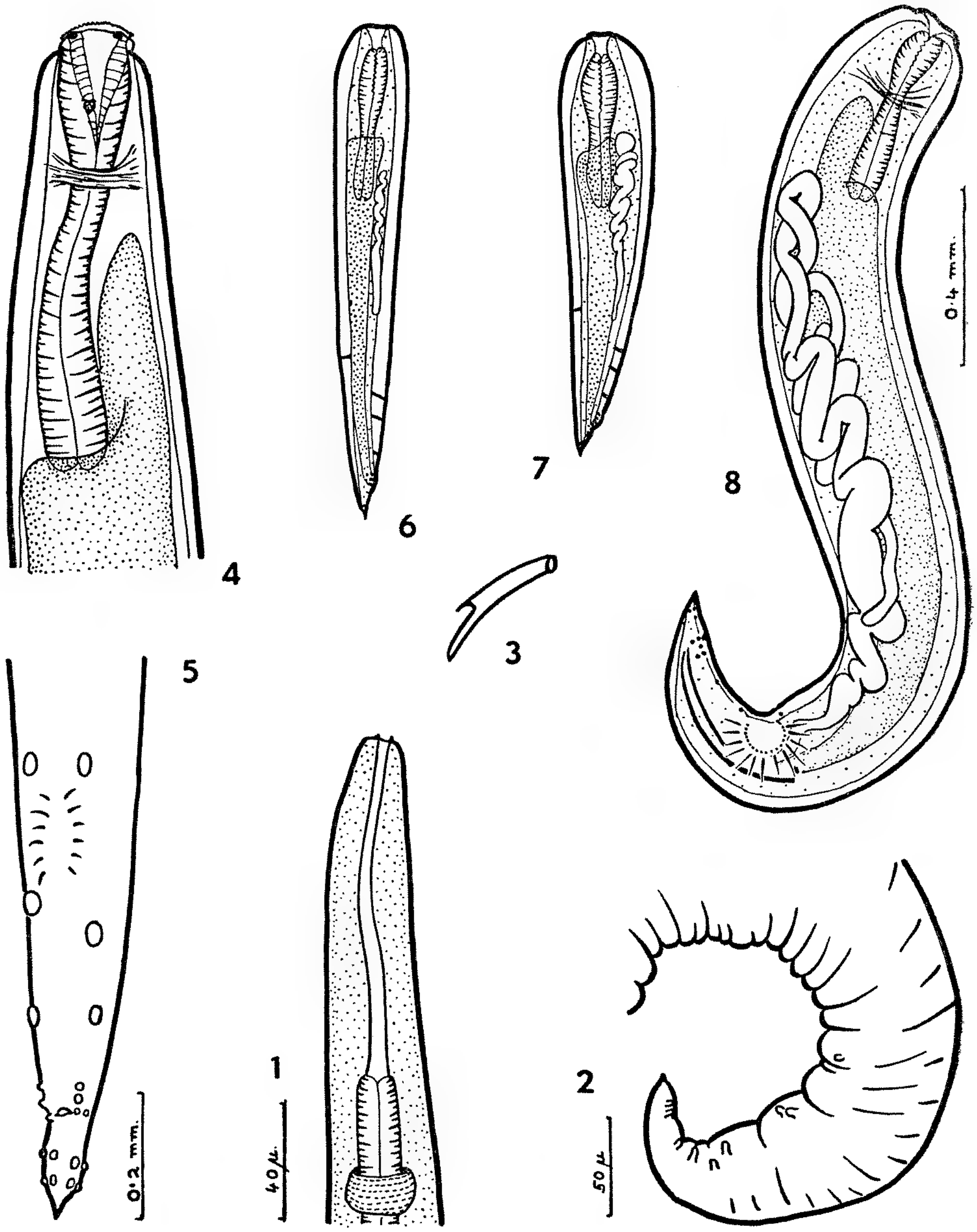

Fig. 1-3, *Ascarophis cooperi:* 1, anterior end; 2, male tail; 3, tip of longer spicule. Fig. 4-5, *Cucullanellus cnidoglanis:* 4, anterior end; 5, male tail. Fig. 6-8 *Cucullanellus sheardi,* successive stages in growth of male. Fig. 1 and 3, drawn to same scale; 4, 6, 7 and 8 to same scale.

end of vestibule to length of vestibule is 1:3·1-4·2. Nerve ring a short distance behind vestibule. Anterior part of oesophagus 1·7-2·3 times as long as vestibule; posterior part 6-7 times as long as anterior; posterior end of oesophagus dividing body into anterior and posterior parts in the ratio 1:3·7-5. Excretory pore at about ·13 mm. behind end of vestibule.

Caudal alae of male very narrow, with four pairs of preanal and six pairs of postanal papillae. Two or three longitudinal rows of bosses on ventral surface between alae. Spicules ·07-·09 mm., and ·31-·32 mm. long respectively; outer part of longer possessing unusual form (fig. 3).

Vulva at beginning of posterior third of body. Ripe eggs 18 by 36μ, thick-shelled, with coiled larva.

These specimens are regarded as belonging to a new species, differing from *A. australis* J. & M. 1944 (also from a South Australian telost) in the position of the vulva, the size and shape of the eggs, the form of the longer spicule and the length of the oesophagus. The species closely resembles *A. nototheniae* J. & M. 1945, but differs in the form of the longer spicule and the size of the eggs. It is easily distinguished from *A. upeneichthys* J. & M. 1945 by the greater length of the vestibule. The female resembles closely that of *A. morrhuae* Beneden, as re-described by Baylis (1933), but differs in the egg size; the absence of an account of the male of that species prevents further comparison.

Cucullanellus cnidoglanis n. sp.

(Fig. 4-5)

From the estuarine catfish, *Cnidoglanis megastomus,* from Port Willunga. The worms were somewhat shrivelled and difficult to roll; consequently the position of the cervical papillae was not ascertained.

Male 6 mm. long; female 7 mm. Head of the usual Cucullanellid type; each lateral "lip" with three papillae. In the specimen figured, the jaws (the two lateral anterior margins of the oesophagus) are protruded through the mouth. Oesophagus ·8-1 mm. long; intestinal caecum ·4-·55 mm. in length. Nerve ring ·32-·35 mm. from anterior end of worm. Excretory pore just behind oesophagus.

Vulva inconspicuous, dividing body into anterior and postvulvar regions in the ratio of 1·4:1. Eggs about 32 by 72μ. Female tail long, ·24 mm., tapering.

Spicules ·8-1 mm. in length; three pairs of large preanal papillae, four pairs adanal, four pairs caudal.

The species closely resembles *C. pleuronectidis* Yamaguti 1935, differing in minor details, *e.g.,* the exact arrangement of the adanal papillae, and the greater length of the caecum relative to that of the oesophagus.

Cucullanellus sheardi Johnson and Mawson

This species, originally described by us (1944, 64) from *Threpterius maculosus* from Cape Borda, is now recorded from *Dactylophora nigricans,* Backstairs Passage and Rapid Bay; *Latridopsis forsteri* from Kangaroo Island; and *Pagrosomus auratus* from Glenelg.

Numerous specimens of various ages were studied. In the case of males we have considered the state of maturity of the testis tubule to be an indication of relative age. The youngest worm was a short, very thin male, ·72 mm. long; others which measured 1·1 mm. in length (fig. 6), were also very narrow. Others which were older, were of about the same length as the latter but were very much wider, because of the relatively wide transparent cuticle surrounding them; one such worm, ·95 mm. long, is indicated in fig. 7. The longest male observed measured 2·5 mm. As we mentioned in our original account, the female is about

4 mm. in length. The presence of a mid-dorsal papilla in the vicinity of the junction of the anterior two-thirds and posterior one-third of the body length in very young males was mentioned in the original description, and has been observed in the present material. Such a papilla has been noted by us in young males of *C. fraseri* (Baylis 1929), and it is possible that its presence is a feature of the genus.

Echinocephalus uncinatus Molin

The larval stage of this species was found encysted in the mesentery or omentum of the following fish:—*Platycephalus fuscus, Pagrosomus auratus* and *Sillaginodes punctatus* from Glenelg; and from *Pseudolabrus psittaculus* from Port Noarlunga.

Proleptus trygonorrhinae Johnston and Mawson

A female of this species, originally described (1943, 187) from *Trygonorrhina fasciata,* was collected from *Aptychotrema banksii* from Rapid Bay.

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THE SIMPSON DESERT EXPEDITION, 1939 – SCIIENTIFIC REPORTS INTRODUCTION, NARRATIVE, PHYSIOGRAPHY AND METEOROLOGY

BY C. T. MADIGAN (READ 10 MAY 1945)

Summary

This expedition through the Simpson Desert by camel was the culmination of several previous investigations extending over many years. The first of these was an aerial reconnaissance in 1929 (Madigan 1929), when several flights were made across the desert in different directions and the name Simpson Desert was given to it. In 1937 a journey was undertaken by motor truck, round the northern end of the desert. In 1938 an account of all the available information on the desert was published (Madigan 1938, Clarke Memorial Lecture), including a review of all explorations in the vicinity to that date, with references. A more complete list of literature on the desert regions of Australia was given in the Presidential Address to Section P, A.N.Z.A.A.S., 1937 (Madigan 1937).

THE SIMPSON DESERT EXPEDITION, 1939 — SCIENTIFIC REPORTS INTRODUCTION, NARRATIVE, PHYSIOGRAPHY AND METEOROLOGY

By C. T. Madigan

[Read 10 May 1945]

Plates V to IX

I. INTRODUCTION

This expedition through the Simpson Desert by camel was the culmination of several previous investigations extending over many years. The first of these was an aerial reconnaissance in 1929 (Madigan 1929), when several flights were made across the desert in different directions and the name Simpson Desert was given to it. In 1937 a journey was undertaken by motor truck, round the northern end of the desert. In 1938 an account of all the available information on the desert was published (Madigan 1938, Clarke Memorial Lecture), including a review of all explorations in the vicinity to that date, with references. A more complete list of literature on the desert regions of Australia was given in the Presidential Address to Section P, A.N.Z.A.A.S., 1937 (Madigan 1937).

The desert was defined as a broad triangle with its apex pointing downward, and resting on Lake Eyre in the south at the junction of the Macumba and Warburton Rivers. Its margins are the Macumba and Finke Rivers to the south-west, the MacDonnell Ranges to the north-west, the Plenty and Thring (Marshall) Rivers to the north, the Mulligan River to the east and the lower Diamantina to the south-east. It lies mainly in the south-east corner of the Northern Territory, but extends into Queensland and South Australia. It lies roughly between latitude 23° and 27° south and longitude 135° and 139° east. The area is about 56,000 square miles.

It had been established, particularly by the aerial reconnaissance, that nothing lay within the borders of the desert but sandridges and scattered claypans. There were no ranges and no water-courses other than the known streams entering from the highlands to the north, and it seemed very improbable that anything was to be found inside, either geological, biological or botanical, that did not occur round the more accessible margins. However, the late Mr. A. A. Simpson, C.M.G., after whom the desert had been named, was still very anxious that the middle of the desert should be crossed on the ground by a scientific party, for up till then the only crossing had been made by a pastoralist, Mr. E. A. Colson, accompanied by a black boy, by camel in 1936. This crossing was made towards the southern end of the desert, practically along the 26th parallel, the border between the Northern Territory and South Australia. Mr. Simpson offered to finance an expedition on a scale that would allow a reasonable scientific staff to make the journey. This offer was accepted, and arrangements were made for a camel expedition in the winter of 1939, as there had been good rains in two successive seasons with floods along the railway line and in western Queensland, and reports indicated that there should be good green herbage in the desert. Under such conditions camels can, and often do of their own accord, go without water for months on end. It was anticipated that there would be a dry stage of at least two hundred miles across the sandridges.

The expedition set out with three definite primary objects, physiography, botany and zoology. Under physiography the chief study in this remarkable desert was the parallel sandridges that run so straight and evenly spaced for hundreds of miles; to attempt to discover their mode of origin, their age, the

source of the sand, their possible extension, retreat or stability, and their relations to former climates and aridity. This was the main attraction to me, as I had already made some contributions on the subject (Madigan 1936) based on the aerial reconnaissance and ground observations in the Birdsville area. A journey through the desert would provide much more information than was given by aerial observations and photographs, and it was for this reason that it was decided to make the crossing from west to east and thus cross the sandridges, instead of from north to south in the lanes between them. The latter, though a considerably longer journey, would have been easier for the camels, but less in the nature of a cross-section of the desert.

The season seemed propitious for vegetation, as indeed it proved to be, and it was determined to make as complete a botanical collection as possible with a view to providing a reliable plant-oecology of the desert regions.

The third objective was the animal life of the desert. Completeness here would be more difficult to achieve and require a larger expert staff, but every member of the party was expected to keep up a remorseless hunt for all creatures great and small, under the guidance of an experienced field collector. It was not likely that the desert would provide much in the way of new plants or animals, but their relative abundance and distribution were of considerable interest.

Lastly, there was the attraction of the purely physical feat of crossing the desert, the fascination of planning to overcome natural obstacles and the great satisfaction derived from plans proving successful in operation.

The outbreak of war seriously affected the preparation and publication of the results of the expedition, as several members, including myself, joined the services, and the activities of other scientific workers were diverted to war purposes. It is only now that the older age groups are being released from the services that it has been possible to make definite headway. A popular account of the expedition is written, but publication is retarded by the exigencies of man-power and paper. The Royal Society of South Australia has agreed to publish the scientific results, and these will appear from time to time under serial numbers in the Transactions of the Society, as the papers are presented and space allows. The present paper is intended as an introduction to the scientific reports, and will include a short narrative as well as a general description of the area, and a map, to which reference should be made for localities referred to in other contributions.

The following Reports have already appeared: No. 1, Biology—Scorpions and Spiders, by V. V. Hickman (Trans. Roy. Soc. S. Aust., **68**, (2), 18-48, 1944); No. 2, Geology—The Simpson Desert Sands, by Dorothy Carroll (*ibid*, **68**, (2), 49-59, 1944); No. 3, Biology—Reptiles and Batrachians, by J. R. Kinghorn (*ibid*, **69**, (1), 3-9, 1945); No. 4, Biology—Hemiptera, by A. Musgrave (*ibid*, **69**, (1), 14-15, 1945); and No. 5, Biology—Fishes, by G. P. Whitley (*ibid*, **69**, (1), 10-13, 1945.

Reports in preparation include Plant Oecology by R. L. Crocker, Sand Formations by C. T. Madigan, Insects by H. Womersley, and Botany by C. M. Eardley.

II. NARRATIVE

The party consisted of nine members, namely, R. L. Crocker, M.Sc., of the Soils Division of the C.S.I.R., as botanist; H. O. Fletcher of the Australian Museum, Sydney, as biological collector; R. A. Simpson as wireless operator; D. Marshall as photographer; A. Hubbard as cook; Jack Bejah in charge of the camels, assisted by Nur Mahommed Moocha; Andrew, an aboriginal from Marree; and myself as leader, navigator and geologist. Nineteen camels were obtained from Bejah Dervish, of Marree, Jack's father. Bejah had been L. A. Wells' camel man on many journeys but was now too old to travel. Seven camels were

required for carrying water, five for the remaining stores and equipment, and seven were riding camels. The camel transport was supplemented by a motor truck for the first hundred miles of the journey, where it could be used before the crossing of sandridges began, in order to increase mobility.

In stores, water was the chief consideration. The camels were to go without, but the nine men would require water for about three weeks, between Andado Station and the Mulligan River. At a gallon a day this would mean some 200 gallons, and for its transport fourteen sixteen-gallon galvanised iron camel canteens were made to my design, together with two four-gallon canteens for reconnaissance work. Other equipment included a Traeger pedal wireless transmitter, theodolite and chronometer, Sestrel aerial compass fixed to a camel saddle, biological collecting equipment supplied by the Australian Museum, two 16 mm. moving picture cameras lent by the Board of Anthropological Research and the South Australian Government, three hand cameras, aneroid, maximum and minimum thermometers, Birkmyre canvas ground sheets, blankets and a 20-ft. by 18-ft. tarpaulin. There were no beds or tents. The rations were for nine men for six weeks and consisted mainly of five 50-lb. bags of flour, 250 lbs. of salted meat, some cases of tinned meats presented by W. M. Angliss (Aust.) Pty. Ltd., and onions and potatoes, besides dried fruits, bacon, honey, rice, condensed milk, and those bushman's essentials, tea and sugar.

The route was to be by rail to Abminga near the Central Australian border, and thence on to Charlotte Waters, the old telegraph station across the border, which was the assembly point where the rail party would meet the camels from Marree.

From Charlotte Waters the scientists would go on by truck to Andado Station, 80 miles away on the edge of the sandridges, and there await the arrival of the camels. From Andado the route would be northward to the junction of the Hale and Todd Rivers, with the truck going on as far as it could, and from near this junction the desert crossing would start on an easterly course to the Queensland Border and thence south-east to the Mulligan River and Birdsville.

From Birdsville it was proposed to follow the Diamantina down to Lake Eyre, and thence round the east side of the lake to the railway at Marree.

The scientific staff left Adelaide by train on 25 May 1939. The truck, supplied by Harry Ding of Yunta, was picked up with driver at Hawker, and in it, on the 27th, the party drove from Abminga to Charlotte Waters where the camels were found waiting. They had already done a journey of nearly 400 miles from Marree in three weeks and had settled down into a good working team, a very important point in preparing for a journey such as this.

There had been heavy rains along the railway line, with several washaways, and our train was the first to run to schedule for some time. Local pastoralists told us they had never seen anything like the feed then growing, which was a good augury for the desert crossing.

There was water in the shallow holes in the Coglin Creek at Charlotte Waters, and some ducks were shot. There were also some little perch in the pools, of which specimens were taken. The fish proved to be of two species, one of which, *unicolor,* was later placed in a new genus, *Madigania.* The other, *Blandowskiella castelnaui,* a little fellow only three-quarters of an inch long, was the first example of this species recorded in South Australia or the Northern Territory. The day was spent in making up the camel loads. The weather was of the delightful kind, typical of Central Australia in the winter time, with a maximum shade temperature of 76° and a minimum that night of 38° F. Flies were in plague numbers, owing to the proximity of stock and human occupation, but in the desert they entirely disappeared. Mosquitos are unknown in the interior in winter.

On 28 May the scientists went on to Andado Station by truck, followed by the camels. The track follows the flood plain of the Finke for some seven miles, before turning north between the sandridges towards Mount Peebles. The flood-plain was conspicuous from its open forest of gum trees among grasses and herbage head high, but the only sign of a true watercourse was a single narrow ditch some ten feet deep in clay. The broad sandy bed 50 miles upstream at Crown Point, so well known and so difficult to cross, had quite disappeared. A wild turkey was shot here and eaten that night at the station, and a pair of crows were seen near the river. Twined among the shrubs on the flood-plain were many small straggling vines (*Cucumis melo*) bearing little green melons called by the natives ilkarta, about the size of gooseberries and quite pleasant to eat.

The country around Charlotte Waters south of the Finke is a stony table-land. There are table-topped hills to the east, where the Coglin joins the Finke, composed of flat-lying chocolate-coloured sandy shales with marked stream bedding and about 100 feet high. There was nothing to indicate their age, but they did not resemble the glacial (late Palaeozoic) sands occurring further up the river. They are probably of Upper Cretaceous or Eyrean (early Tertiary) age. On one of these table-tops at the Finke close to the Andado track, a place called by the natives Koppadeitchaka, where there is a stone cairn, not the trig. point of Mount Wilyunpa which is three miles to the south, was found what appeared to be an unusual aboriginal work. It was a sort of long narrow yard enclosed by stones. It was open at the north end, from where two parallel lines of stones eight feet apart ran south for 44 yards, where they opened out to 20 feet apart for another 20 yards and then joined in a curve. Inside the wide part there were many large flat stones turned up on end, without any definite arrangement, and also others outside the yard, many of them projecting several feet above the ground. It may have been an imitation cattle yard, but seemed too laborious an undertaking to represent mere "fun-games." The dislodged stones might have been connected with building the cairn, but not so the yard.

The sandridges begin immediately across the river valley on the northern side of the Finke. The track to Andado, after leaving the valley or flood-plain, swings north-north-west between parallel sandridges for 15 miles to a stony patch on which Mount Peebles, Mount Day and Moolta Hill are conspicuous features. These hills are all low flat-topped residuals on the sandridge-free area, which is about 30 miles across east and west and 12 miles north and south. Mayfield's Swamp lies near the river between the sandridges. At the time it was a large sheet of shallow water surrounded by box gums, with a few ducks on it. There were no signs of water in the Finke itself at our crossing.

Andado Station lies in the edge of the sandridges just off the eastern end of the stony patch of ground mentioned above. It is necessary to cross two 50-ft. sandridges to reach it. An ill-defined watercourse runs along the lane between the sandridges, and good water is found in a well at 60 feet at the homestead. There are innumerable similar sites that should be equally successful for well-sinking in the desert areas. This is normal ground water, not the artesian supply, which lies 800 or 900 feet below the surface and is much inferior water.

A surprise awaited us at Andado. We found that the rains had missed that locality and only two inches had fallen in the last six months. The place had a desolate appearance and there was practically no feed about. Bejah took the camels further north on the track to the Bore No. 1, where some herbage was found. It was felt that this state of affairs should only be local, as there had been heavy rains not only along the railway line but also in Western Queensland and the Birdsville area on the other side of the desert.

A mishap occurred to the wireless at Andado. For some unknown reason all three transmission valves blew out and it was necessary to get more spares up

by train. This detained us a week at Andado, but the time was well spent. The accident was disconcerting as the cause remained unknown, but fortunately it never happened again. During the wait, cross-sections of sandridges were measured and films were taken of sand-drifts, aboriginals at the station camp and other subjects of interest, the position of the station was astronomically fixed, biological and botanical collections were made, and the meat was killed and salted. The pretty little hopping brush-tailed marsupial mouse or fawn jerboa mouse (*Ascopharynx cervinus*), first collected by Sturt, was common in the sandridges round the station, but other mice captured here proved to be the common introduced mouse. Only one other species, the fat-tailed marsupial mouse (*Sminthopsis crassicaudatus centralis*) was taken on the whole expedition.

On 4 June the party got away from Andado and proceeded on to Andado Bore No. 1, 25 miles to the north of the station. The lane between the two sandridges at the station was followed for ten miles, when another stony area was arrived at, on which the bore is situated. This bore is 870 feet deep and the water stood at 70 feet from the surface. It had not been used for some time. At the bore occurs one of the only two groves known in Australia of the tree *Acacia peuce*, the other being near Birdsville. It is known as Casuarina at Andado and waddy at Birdsville. It is a tall, straight tree 50 feet or more high with thin drooping foliage and seeds in long pods. It is not unlike a Casuarina or sheoak in general appearance. The wood is very heavy, red and hard. There are only 50 or so trees remaining at each locality, and the timber is in such demand that it is likely that it will all soon be cut out.

The truck was sent back from the bore as at most it might have made another 40 miles to the north, after which the easterly course across the sandridges would have been impossible for it.

The stony patch on which the bore lies extends as a narrow tongue northward to the Hale-Todd junction, as was afterwards discovered, but the party made straight for the approximate position of the junction, cutting across a bay in the stony tongue. In this bay the sandridges were close and small and clothed with spinifex. There was not a living tree there, but quite a lot of scattered and dead mulga. Across the bay the stony tableland was met again and followed along the west side to its pointed end. The edges were here abrupt, rising some 50 feet above the plains. The table-land was composed of porcelainized shale capped by a pebbly conglomerate up to ten feet thick. The locality at the point is known as Poodnitera. There is a round table-topped hill standing out from the main tableland on the west side, and a mile to the north were two round-topped twin hills with a cairn on one of them. From the Twins a good view is obtained. The Todd comes in from the north-west, an ill-defined watercourse among the sandridges, and passes just north of the Twins to join the Hale, known locally as the Illitera, at a point about four miles away east by south. The Hale comes down from the north in a straight and better-defined course from a tableland edge about eight miles to the north. There had been rain here and camel feed was plentiful, including buckbush and munyeroo.

An old blackfellow had been brought from Andado to locate a native soak on the Hale some miles above the junction, from which point it was proposed to turn east after filling up with water. A course was taken from the Twins to meet the Hale about eight miles above the junction, where it flows along a high rocky bank on the east side.

Although the course of the Todd had seemed obvious from the Twins, owing to scattered box gums, we crossed it on the ground without being aware of it, and passed through very close sandridges for six miles before converging on the flood areas of the Hale, where the herbage was as dense as it had been along the Finke, with flowering acacias in addition. Birds were plentiful along the Hale,

including budgerigars, zebra finches and pigeons, and emu tracks were noted. There was no open water anywhere about, but dews were heavy.

The Hale here showed a single well-defined channel, little more than a gutter, like the Finke, but it was obvious that in times of flood it would cover considerable areas.

We camped on 7 June on the Hale under the low cliffs on its east side near their southern end. A light rain fell during the night, about 10 points, sufficient to make everything unpleasantly damp. A day was spent searching for the soak. The old aboriginal seemed a little uncertain of the locality, but it was eventually found to be another seven miles upstream, or 15 miles from the Twins (Poodnitera). At this camp a good colour film was made by Marshall of Andy, our aboriginal, cutting out widgettie grubs from a gum tree and eating them. There was a rabbit warren near the camp and a few rabbits were seen. These, with another at the bore, were the only rabbits noted in the whole desert crossing, the next being along the Diamantina far below Birdsville.

On 9 June camp was moved up to the soak, which proved to be Allua Soak, already mapped by Day. The east side of the Hale all the way was marked by a 50-ft. stony ridge, often with deep bays in it. The trend of these low cliffs and of the river up to this point is about 10 degrees west of north, which is an exception to the rule that all streams run parallel to the sandridges in the desert, a rule that always holds in the level plains, where the trend is 30 degrees west of north. To the west were level sandridge plains. At the soak the river has a single wide sandy bed 50 yards across, which is typical of its course from its source in the MacDonnell Ranges to this point, but below the soak it breaks up into small gutters and channels without sand.

Excellent water was found in the river bed three feet below the surface and all canteens were topped off and the camels offered a drink, but most of them refused or took very little. There were emus nesting near the soak and some eggs were eaten. Yams were plentiful in sandy banks, and widgettie grubs in the trees. It had been an important locality before the aboriginals became detribalized, and there were many signs of native occupation. It was discovered afterwards that our old guide remained there for three weeks after we left him, before returning to Andado.

Stars were visible that night for the first time since leaving Andado, and an astronomical fix was obtained for the soak, the point of departure for the eastward crossing of the desert. A course of three degrees south of east was set for "Mudloo Well," a point marked on the map just across the border in Queensland, about 150 miles away. We had no information about this well.

The crossing began on 10 June, with a load of 232 gallons of water. The cliff, there over two miles from the river, was scaled by means of a watercourse, and we found ourselves on a level stony plain. After three miles of this another valley, about three miles wide, crossed our path. It trended away south-southeast, with a stream bed in the bottom. In it were green acacias, gums and herbage, with many budgerigars and finches, but no water. For the first few miles beyond this valley the plain was stony, with a few small sandridges, odd claypans, and some small dead timber. In lower areas there was living mulga and green herbage, but the gum trees were all dead. Zebra finches were still numerous in these green patches.

From twelve miles east of the river the country rapidly deteriorated. The sandridges became straighter and more regular and closer. Seventy sandridges were crossed in 16 miles on the second day, the later ones rising to 50 feet high, and only a few stony patches were seen, sand now covering the lanes between the ridges. Spinifex became the universal plant, with a few succulents on the crests

of the sandridges, but camel feed was becoming scarce. On the next day 73 sandridges were crossed in 15 miles. One dry but tree-covered claypan was passed, but conditions were steadily deteriorating. Camp 8 was reached on 13 June, after crossing 55 sandridges rising to 80 feet high in 13 miles, which took six hours of travelling. This was the average spacing of the sandridges, four to the mile. We were now in country that had had no rain for at least a year, and probably two, for the spinifex had not flowered, and most of it was dead. During the afternoon a patch was entered where rain had recently fallen, as the spinifex was in flower and there was green canegress, but camel feed was still inadequate. On the far side of this green area Camp 8 was made between the sandridges where there was a clump of needlebush, the first so far seen. Rain came on in the evening and kept us in camp for the next three days, during which time over an inch fell in an almost continuous drizzle. About 30 gallons of water was caught on ground sheets, in which water beetles were found swimming, at first a profound mystery, but later it was realised that they had flown there on the east wind from claypans further east. The rain wetted the sand to a depth of 15 inches. This camp was 60 miles east of the Hale and geographically about in the middle of the desert. A national broadcast was sent out from here over our little pedal set, to be picked up and relayed over land-lines by Harry Ding at Yunta.

A cross-section of several sandridges was measured at this camp, and a series of soil samples taken. The posthole-borer would only go down 11 feet in between the sandridges, at which depth sandstone gravel was met, indicating the proximity of the solid sandstone. Although there was still no surface water, wrens and chats were found round the camp.

Camp 8 was left on 17 June. The going was rather easier at first, with some groves of mulga between ridges, and three little claypans with water, the first open water seen since leaving Charlotte Waters. The recent showers had filled them. Budgerigars, crows, finches and chats were noted. Dingoes were first heard along the Hale, and thereafter almost every night during the desert crossing their occasional yaps and howls were the only sounds to break the silence. They were often seen peering over the crests of sandridges. No emus, kangaroos or rabbits were seen during the crossing. The most conspicuous creatures were lizards and an occasional snake. Mouse holes were common, but only yielded the two kinds of marsupial mice mentioned above.

Between Camps 9 and 10 conditions became very difficult. The rate of travelling was only averaging two miles an hour and six hours was enough for a day. The sandridges were up to 100 feet high, and one had to be crossed every seven or eight minutes. Camel feed had practically disappeared and the beasts were beginning to fail, several falling during that day. The last summer rains had not reached the western side of the desert at all. It was obvious that a crossing would be impossible unless feed were better, but to return was now as hazardous as to go on and probably more so, as on any day we expected to reach the areas covered by the Queensland rains. Scarcely enough dead needlebush could be found to make a fire. There was nothing to be seen but sand and spinifex, and nothing to be done but push on hopefully. Camp 10 was left on 18 June. From the crest of the second sandridge from the camp, not half-a-mile on, there was suddenly seen a claypan full of water in the valley before us. The claypan was found to be surrounded by great mats of munyeroo, a portulacca that makes very good camel fodder. so camp was immediately made again and the camels turned out to feed, at Camp 11.

This proved to be the edge of the Queensland rains and all difficulties were over. The feed steadily improved to the east, and the camels eventually arrived at Birdsville in even better condition than they left Andado.

On two sandridges away to the north-east of Camp 11 there was a group of five claypans up to 50 yards across, covered with a few inches of water. These claypans were surrounded by living gidgee and there were small exposures of silicified sandstone around them, with flint and ironstone nodules lying about. Here we discovered the signs of visits by aborigines in the form of chipped flints and broken grinding stones,, one grinding stone of schist suggesting that it came from the MacDonnell Ranges. Although the natives from the south of the desert and the Diamantina always deny all knowledge of the desert, obviously fearing it and maintaining that no one ever went into it, it is clear that other tribes from the north have penetrated a long way in by following the streams down from the MacDonnell Ranges in times of rain.

A clear night made observations for latitude and longitude possible at Camp 11, the first opportunity afforded since we left the Hale. It was found that dead-reckoning distances were correct to a mile in 80, but the crossing of the sandridges at a small angle had caused a definite drift to the south, which on later courses was slightly over-corrected.

From Camp 11 a course was taken north-easterly to re-locate some large claypans plotted on the aerial reconnaissance. These were found as marked, but no attempt was made to map them in detail. Several lanes were seen to the north full of dark gidgee trees, and several small claypans and two large ones were passed, both containing water, one as much as 200 yards across. The water was only a few inches deep, recently fallen, and would dry up in a few weeks. The camels were not interested in drinking. The claypans ceased several miles before Camp 12 was reached.

The sandridges were now dwindling in height, reaching only about 30 feet, and the herbage was daily increasing. There was green sandhill wattle, water-bush, buckbush, hopbush, flowering grevillea, grasses, and seeding spinifex. The spinifex grew everywhere except on the live sand of the crests, which was favoured by everything but the spinifex. Between Camps 12 and 13 a few white-stemmed gum trees were seen. A second national broadcast was given at Camp 13.

As the Hay River was approached the sandridges became low and irregular. Eighty were crossed in 16 miles between Camps 13 and 14. In the heart of the desert the sandridges had been red and forbidding, serrating the horizon with their jagged crests, but now, from the top of a ridge, the country looked flat and the yellow spinifex stalks gave it the friendly appearance of a great wheat field.

For a week after the rain the nightly dews were extraordinarily heavy, and everything was covered with a film of water every morning. The dews later changed to frosts, as had been experienced in the earlier days of the journey.

For a mile before reaching the Hay odd box gums were noted between the sandridges, and then suddenly the valley of the Hay appeared. It was merely a sandy-floored depression up to 400 yards wide, covered with scattered box gums of meagre growth, and abundant acacias and herbage. There was a single small watercourse winding along the valley, but no signs of torrential floods. It was a dead river valley. The bed of the channel was of fine sand. In one place the bed showed about 100 yards of crusty silicified rocks similar to all the desert rock surfaces.

We followed the Hay down for ten miles. It ran S.30°E., parallel to the sandridges on either side. Birds were fairly numerous. Budgerigars were in large flocks, and there were also a few galahs, and crows, hawks, zebra finches, and some smaller wrens and chats. It seemed that dew could be their only water, as we knew of none within 50 miles. A single turkey was seen and secured for the pot.

Astronomical observations were taken at both Camps 15 and 16 on the Hay. The position agreed with that given by Winnecke, who had come down the river in 1884 to a point about 15 miles above where we first struck it. Camp 16 was 17 miles west of the Queensland border at a point 86 miles north of Poeppel's Corner. A tree was marked at Camp 16 with $\overset{\text{M}}{39}$, the largest tree that could be found, which was about a foot in diameter.

The third and last national broadcast, in which all members participated, was given from the Hay River.

A few dry claypans were seen close to the Hay on its east side. The country again became much drier between the river and the border, with the sandridges rather higher, very few trees, and dense spinifex. It was the bad belt of country in which Sturt turned back in 1845.

Camp 17 was on the Queensland Border, but no signs could be found of the old survey party or Wells' mile posts and quarter-mile pegs put in over 50 years before.

From Camp 17 a course was set for old Kaliduwarry Station on the Mulligan, 44 miles away. Although near it, we decided not to try to locate Mudloo Well, as we did not need water, and it probably belonged to border survey days and might long have disappeared.

At the border the country showed a marked change. The sandridges became further apart, straighter and higher, up to 60 feet, and instead of dense spinifex between them there were clumps of gidgee, gradually becoming more continuous till they ran for miles along the valleys. The country became greener again with some saltbush appearing in the lanes in clay and limey soils instead of sand. The sandridges were now being crossed obliquely at the rate of 15 or 16 a day.

A few miles short of the Mulligan a long white lake was crossed, dry, but covered with salt and gypsum and extending as far as the eye could see to the N.N.W. and S.S.E. Soon the once rabbit-proof fence was encountered five miles west of the river, and at last Camp 20 was made on the river itself on 28 June. Near the river the sandridges had died down to mere broad undulations.

The desert had been crossed from the Hale to the Mulligan in 19 days, over 626 sandridges in a distance of 204 miles. We arrived with 77 gallons of water in the canteens. Thirty gallons of rain water had been added to our supply on the journey, and consumption had worked out at 10 gallons a day for nine men. Actually we could have refilled half-way across the desert at the claypans, but such a fortuitous finding of water could never be relied on. Water restrictions had been somewhat relaxed during the latter part of the journey. At first the two 4-gallon canteens had been filled daily and no more water could be used.

The Kuddaree Waterhole on the Mulligan was a fine sheet of water 600 yards long by 100 wide. There were teal and several larger kinds of duck, geese, black swans and cranes on it, and in the trees large swarms of corellas and some galahs. A mile to the east there was another smaller waterhole, by which stand the remains of the old station building.

We were held up for another two days here by rain, but at length continued on down the Mulligan to the deserted Annandale Station. The cattle had all been removed from the Mulligan at this time and the stations closed, though feed was now everywhere about in great abundance. Near Annandale we had to weather another two days' rain, during which an inch fell. By this time the river flats were a series of shallow lakes; in fact, the whole journey of 75 miles from Kalliduwarry to Birdsville was a most miserable one, with rain, bitter winds and water lying about everywhere, so that the camels sloshed and slipped along and we had to pick our way between the bogs. It was so cold that the party preferred

to walk most of the time in spite of mud and wet feet. The sandridges became quite friendly, providing, as they did, much better going as well as the only dry places to camp on. The whole journey was made under exceptional conditions. Far from suffering from lack of water, we suffered from a surfeit of it.

Between Kalliduwarry and Annandale the Mulligan showed a well-defined channel with sandy bed about six feet deep and 25 yards wide, in a broad valley flanked with sandridges and well timbered with box gums, in the hollow trunks of which the budgerigars were nesting in hundreds. Below Annandale the river breaks up into braided channels. All waterholes were full, but it did not seem that the river had run for many months. From about eight miles below the station we took a direct course for Birdsville, as no tracks could be found. This took us through sandridges all the way. The track actually takes a curve to the south and avoids most of them.

The country between the Mulligan and Birdsville was of a quite different character. Instead of the sandridges running through a sea of sand they were separated by bare gibber plains. All the sand was swept up into ridges which were spaced more irregularly. The average distance apart was two-thirds of a mile instead of the quarter mile in the desert, but there were often plains up to two miles wide separating the most impressive sandridges we had seen. They looked like mountain ranges across the level stony plains. Actually they were no higher than some of the desert ridges, one measuring 77 feet 6 inches against an 86-ft. ridge at Andado, but the sides were steeper, without the long and gentle approach which lessened the apparent height of the desert ridges. The sand of the ridges east of the Mulligan was of a light buff colour, and not the deep red of the desert. This was also the case along the Diamantina and round Lake Eyre, where it was almost white. Emus were again seen on this side of the desert, but no kangaroos till we were well down the Diamantina.

Birdsville was reached on 6 July, after a journey of 347 miles from Andado Station or 427 miles from Abminga. After four days' rest at Birdsville the last stage of the journey was begun, the return to Marree *via* the Diamantina and Lake Eyre, a distance of some 400 miles. This was through known country, most of it occupied for cattle-raising at one time or another, but now practically deserted. The paradox was that never in the memory of living man had the country looked better. Drovers had never known the "Birdsville Track" to Marree to be in better heart, and mobs of cattle were moving down from Queensland at intervals of a few days apart. Statistics show that good seasons occur about once in nine years. The present conditions were causing one of the periodic revivals of interest in the country, with several new enterprises starting, all doomed to go the way of their predecessors, unless new methods and more organisation are introduced. Erosion has had little effect on the Diamantina country in South Australia. Its failure is due to the simple fact that not only is the average rainfall five inches, but it is so erratically distributed that the actual rainfall may be only from one to two inches for many years in succession, followed by a 10- or 11-inch fall often in two successive seasons occurring at intervals of about nine years. The rainfall is better described as 10 inches or nothing a year. There is no evidence that the country has "gone back" except round the waters, and there were no signs of recent sand drift around the four deserted homesteads visited along the Diamantina, namely Goyder's Lagoon, Mount Gason, Cowarie and Kalamurina. The country is much the same as ever it was, lakes and meadows one-fifth of the time, parched and almost barren plains four-fifths of the time. Occupation began in the 1880's, and several places opened and closed finally before the end of the century; others have been reoccupied from time to time ever since. Conditions were no better in the beginning. The only way to make any use of the country is to exploit the good seasons and withdraw in the bad. Cattle can-

not live when the feed is gone even if water is provided. Rainfall controls the stock-carrying capacity of these vast areas. Any talk of irrigation except in narrow belts along rivers is quite fantastic.

The Diamantina runs a channel flood almost every year, and was running strongly at this time. It was an opportunity to find out what eventually became of the water, and whether Lake Eyre was still dry after the two exceptionally wet seasons. The investigation of Lake Eyre was the chief object of this part of the expedition.

From Birdsville the party followed the fine-weather mail track as far as Mount Gason. The track keeps close to the edge of the sandridges on the west side of the Diamantina as far as Goyder's Lagoon, where it turns and crosses to the east side. The sandridges everywhere near the river were a mass of vegetation. The most conspicuous plant was the wild stock (*Blennodia pterosperma*), which completely covered large areas with its mauve and yellow flowers. Giant buckbushes grew to six feet in diameter.

Andrewilla Waterhole, a permanent water six miles long, was visited. Good edible perch (*Hephaestus welchi*) were caught here on hand lines. It was surprising to find later that they were known only from the type taken at Innamincka on the Cooper. The trees at the waterhole were crowded with flocks of cockatoos, mostly corellas. Birdsville received its name from the abundance of bird life along the river. There were a few ducks and other waterfowl, but ducks were far more abundant on the temporary waterholes along the track.

Goyder's Lagoon was crossed obliquely at its western end. It is a level clay flat covered with interlacing channels which are lined with lignum bushes, all dead at the time. The gutters are from 10 feet to 30 feet across and no more than three or four feet deep. They were running full, with the level of the water not more than an inch below the ground surface. We had taken some risk in attempting to cross with camels, but the cattle were still using the track. The whole surface was carpeted with yellow daisies and billy-buttons in bloom. There is no timber on the lagoon with the exception of "One Tree," and firewood had to be carried. We were crossing gutters for about 10 miles, a dozen in the first five miles. A canegrass swamp half-a-mile wide and under water gave the greatest difficulty on the far side, beyond which a small rise brought us on to gibber flats, part of Sturt's Stony Desert, where the sandridges are fewer and much farther apart.

On a long narrow waterhole close to the ruins of Goyder's Lagoon Station we found ducks in thousands. There were several kinds, and shooting them was like mass murder. When fired on they merely flew up and down the narrow water and soon settled again.

We crossed the Warburton (Diamantina) just below the Kallakoopah branch and went into the yellow sandhills between the rivers, re-crossing again lower down at Bulkalara crossing. The river was running a few feet deep at the crossings, as it had been at Birdsville. The channel of the river below Goyder's Lagoon is very well defined and is mainly about 50 yards wide between clay banks 20 to 40 feet high. It is a series of pools connected by shallows and reminds one much of the Darling.

Near the river opposite Mount Gason we saw a group of five kangaroos, the only ones seen on the whole journey. There were also ibis on the swamps, and emu tracks in the vicinity.

Near Cowarie we were again in sandridges decked with flowers, including broom, stocks and daisies, all in bloom. There is a complete and striking absence of spinifex in the sandridges south of the Warburton and all round the east side

of Lake Eyre. The climate is the same, the sand cannot vary much, yet a hundred miles to the north there is very little else but dense spinifex. It may be that the high gypsum content of Lake Eyre sand is inimical to the spinifex.

Between Cowarie and the remains of Kalamurina Station the course lay along the edge of the sandridges and on the river flats. The box gums round claypans near the river were all dead in this area. Between Kalamurina and the lake we travelled mainly across the yellow Lake Eyre sandridges. Here there was less herbage, but a mat of wiry grass covered sandridges and inter-ridge lanes alike, giving the whole landscape a black appearance. The grass was drying off and was very slippery to the camels' feet. This grass was found all down the side of the lake, and there was little else except buckbush, which was profuse, and a few scattered needlebushes, the only timber, which was so scarce that it had to be searched for to build a fire. At the lower end of the Warburton the channel was as much as 150 yards wide, and full from bank to bank. No movement of the water could be detected.

We could go no further west than Camp 42, where the Kalaweerina Creek runs south into Lake Eyre from the ring formed by the Warburton and Kallakoopah, as we could no longer cross the waters. The Finke and Macumba also join this ring, but whether the main inlet into Lake Eyre is Kalawerrina Creek or another bay further to the west, or whether the waters are shared by both inlets, we had no means of knowing. At Camp 42 three broad placid waterways met, and there did not appear to be definite movement of the water in any direction. Floating sticks went both ways with the breezes. There were a few scrubby box gums along the creek near the camp, and some lignum, neither persisting to the south, and a few rabbits.

The water in the claypans and waterholes along the Mulligan and Diamantina had been white from suspended clay, often as opaque as milk, but here, under the flocculating effect of greater salinity, it was much bluer. All the water subsequently seen in arms of the lake was quite clear, and in most places it was saturated brine. At Camp 42 the water was still drinkable.

An account of Lake Eyre (Madigan 1930) had been written after the aerial reconnaissance and ground expedition of 1929, just 10 years earlier. That was at the end of a long drought period and the lake was completely dry, with a salt crust as much as 17 inches thick at 12 miles from the southern end. This present visit was after two exceptionally wet seasons, and it was of interest to see how the lake had been affected. We followed the brimming Kalaweerina Creek down for eight miles, but there an arm extending to the east cut us off from further progress south and we could not reach the surface of the main lake at the north end. The creek had spread out on entering the arm and no channel could be seen. The water was now only a few inches deep. It extended south-east down the arm for about 10 miles, where it ended. A few ducks and swans had been seen at Camp 42, but round the shallow water in the arm there were tremendous flocks of sea birds, mainly gulls and terns. Towards sunset they were moving about in clouds. No birds at all had been seen 10 years before. Stories of natives collecting birds' eggs had been used as an argument that the lake was always full. As the Diamantina appears to reach the lake every year it is probable that birds do breed annually at the north end in the arms and swamps, if not on the lake itself, but towards the south end the salt crust is so thick that it can rarely go into solution, the 17 inches requiring nearly nine feet of water to dissolve it, so that any water on most of the area of the lake would always be a brine and birds would avoid it, as was found to be the case on this journey. The birds' eggs no longer interest the few aborigines who are now all segregated round the stations or towns. Not a single man or beast was seen in the 200 miles from Cowarie to Muloorina.

Other arms of the lake, all dry, kept us away from the margin and it was not till after crossing the Cooper that we were able to get in to the real shores at a point about half-way down the east side of the lake, for though there was no water in the arms their clay beds were damp and too soft to risk a crossing with the camels. From the sandridge running parallel to the shore, the white surface of the lake could be seen extending to the horizon about five miles away. There was no sign of water. We walked out nearly three miles over the damp buff-coloured gypseous clay surface, in which our feet sunk about half an inch. Occasional large pieces of driftwood were seen, that would take a foot of water to float them, and ants and spiders were found at intervals all the way, indicating that it was a long time since the driftwood had been carried there. The spiders proved to belong to two species new to science. Previous experience had shown that the lake margins slope gently inwards and that the salt crust may be up to four miles from the shore. We did not reach the salt in our hour's walk.

That night on the lake shore was the coldest of the whole journey, the minimum thermometer falling to 23° F. at grass.

In the sandridges near the shore at this point there was a long narrow lake which had a few inches of water on it for a distance of about a mile. The water was brine, with salt crystallizing out round the margins. There was no drainage running into this lake, as is the case with most of the scattered and detached lakes in the sandridge country on the east side of Lake Eyre, and the water represented only local infall on the lake floor, gathered towards the centre.

Again we were kept from the margin by an arm running inland, but after rounding this a southerly course brought us to the shores again in the south-east corner of the North Lake. Camp 49 was at the channel connecting the Clayton Lake, which receives the waters of the Clayton and Frome Rivers, with Lake Eyre. The neck was a mile wide, with a quarter of a mile of water half an inch deep in the middle, a saturated brine that was already depositing its salt. It was easy to walk across, but the camels began to bog, and the attempt to take the string over was abandoned.

The channel connecting the north and south lake was revisited, this being the vicinity of the ground expedition to the lake in 1929. The channel had gutters in it, running crosswise and lined with shrubs. This showed clearly that any water in the channel comes from run-off from the shores, and that the saline waters of the lakes never now pass through the channel. No herbage ever grows on any of the lake beds, which are always completely bare. The former visit to the channel had been to a point a mile or so to the south, where it was wider and was then covered with a salt crust. Half-way between the connecting channel and the Frome entrance we found the tracks of the truck used on the 1929 journey and followed them for over a mile out on to the lake. They were almost as clear as when they were made 10 years before.

These observations confirmed my belief that Lake Eyre is never completely covered with water, but that when floods come down, which is almost annually in the case of the Diamantina, two or three times every 10 years in the case of the Macumba and Frome, and never since 1917 in the case of the Cooper, then the waters spread out on the swamps round the river mouths, which are themselves vast areas in all cases, and may extend out on to the lake, but only in the vicinity of the river entrances, where their depth is soon measurable in inches and they disappear in a matter of months under the effects of evaporation which is of the order of 100 inches a year.

As we were unable to make a short cut to Muloorina across the neck, we had to go round the Clayton Lake, as I have named this arm of Lake Eyre, Lake Frome being preoccupied. Clayton Lake was dry as far as could be seen, but boggy. We safely crossed some of its arms.

The only creatures other than insects and reptiles seen round the lake were crows, that were nesting very obviously in the few needlebush trees; also the beautiful little orange chat in considerable numbers, and an occasional skylark. In spite of the exceptional vegetation and some bird life, the Lake Eyre region still retained its eerie and depressing atmosphere of vast silence, desolation and death. This was thrown into even greater relief on our arrival at Muloorina Station, which had been re-opened after its original closure as a cattle station in 1902, and its long use as a Government camel depot followed by another 10 years of desertion. Now it was a flourishing sheep station with shearing in full swing, and has so continued successfully up to 1945.

Marree was reached on 8 August, after a journey of 800 miles in a little over 10 weeks on the camels, and the party returned from there to Adelaide by train.

The Expedition has accomplished what it had set out to do. The desert had been crossed; much more had been discovered about the nature of this unique physiographic region with its remarkable ribbing of sandridges; Mr. Crocker had made a very complete plant collection under most favourable conditions; all members had assisted in the collection of animal life, in which the energy and keenness of Andy the aboriginal had been outstanding, and Mr. Fletcher had made an excellent job of the care and maintenance of the collections under difficult conditions. Little was done with birds other than the observations recorded in this narrative, only five species having been actually taken, all in the middle of the desert and none of them new, though the crimson chat and banded whiteface are rare and beautiful little birds. The reptile collection, however, was described as an excellent one, comprising 18 genera and 23 species, some of them exceptionally rare. Of 28 species of spiders, 14 of them were new. The insects included 80 species. One of them, *Varnia perloides,* is known only by a single specimen in the British Museum. Only three mammals were collected, the two marsupial mice and one introduced mouse, and no others were seen except dingos and rabbits. The desert had given us all it had to give, and these poor offerings will be found described in greater detail in papers by various authors appearing in the Transactions of this Society under the heading of the Simpson Desert Expedition 1939—Scientific Reports.

III. PHYSIOGRAPHY

The natural features along the route have been described in the narrative above, and a full account of the physiography and geology of the region as far as then known was given in the address, "The Simpson Desert and its Borders" (Madigan 1938). This crossing confirmed previous observations, but added little that was new except a series of levels. The country between camps in the desert is described in words on the map, the notes including the nature of the sandridges, whose trend is shown by the dotted lines, the vegetation and the occurrence of claypans. The margin of the sandridge area is shown practically as before. It is very definite to the west and south, being the Finke and Macumba in the west, and Lakes Eyre, Gregory, Callabonna and Frome to the south (the borders of the Northern Flinders Ranges), but the eastern border is indefinite. The Mulligan and lower Diamantina (Warburton) form a definite margin to the desert, but not to the sandridges, which extend a hundred miles and more to the east of those rivers. The desert is a monotonous sandy plain ribbed with close sandridges and covered with spinifex, but east of the line of the rivers mentioned the country is broken by occasional low stony tablelands and tabletopped hills (mesas and buttes) and is characterised by stony gibber plains known as Sturt's Stony Desert in the north-east corner of South Australia, but extending northward through Birdsville into Queensland. The sandridges in this country are large and isolated, often several miles apart. In the region of the Strzelecki Creek, south of the Cooper, they are again smaller and closer in a bad patch of desert.

The limits of the map obviate the necessity of committing oneself to an eastern margin of the sandridge area, but it may be taken approximately as the latitude of Lake Frome to the south and the 141st meridian, the border of South Australia, to the east. Sandridges are not a notable feature of the north-west corner of New South Wales, but there is an extension into Queensland east of Innamincka. It is everywhere a fading and indefinite margin to the east.

The northern limit of the regular sandridges was plotted from aerial observations and from Winnecke's explorations. To the north-east they end against Winnecke's Adam Ranges, a group of tabletops, but to the north they fade out into a featureless sand plain which is broken by the Dulcie, Jervois and Tarlton Ranges, but extends beyond them as red sandy loams for hundreds of miles to the north. The northern limit of the parallel sandridges is closely associated with the margin of the artesian basin, suggesting that the greater quantities of sand are derived from the erosion of the Upper Cretaceous and Eyrean sandstones that cover the basin in this lower area, as well as to the fact that the desert receives the inwash from all the streams from nearly half a million square miles of country.

As regards the cartography, there are several new features on the map as well as changes of position of old ones. Attention was drawn to some of these points in a former paper (Madigan 1938), namely that the Marshall River joins the Plenty, and it is the Thring that runs east to join the Arthur and form the Hay River; that the Arthur does not run through the Tarlton Range but down the west side of it, and that Goyder's Pillars are on the middle of the Range and not on the river. The river runs between two small ridges five miles west of the Pillars, and these ridges have wrongly become known as Goyder's Pillars. The Hay River was fixed by longitudes at the Tarlton Range and also at Camps 15 and 16. These positions agree with Winnecke's, and are 9 to 10 miles to the west of the position shown on present-day maps. The map presented with this paper shows the Field River as Winnecke placed it, which is 7½ miles west of that given on most maps. I have not visited this river, but it is obvious that both rivers have been plotted from Winnecke's route survey, and both moved east, the Hay definitely wrongly so. This move was made to allow Winnecke's Field River to agree with Wells' (Border Survey) position for Gnallanageer Creek which crosses the border. It would be surprising but possible that Winnecke should be correct for the Hay River and so much out for the Field. On the other hand, the Field may not have been conspicuous where it crossed the border, so that Wells' Gnallanageer may not be the same as Winnecke's Field River or the Alanajeer of most maps, or it may be that the Field makes an unexpected kink at the border. No one seems ever to have followed the stream right down.

It is considered that the lower reaches of the Hale are much straighter than usually shown, with one well-defined channel. The width is usually exaggerated. The Hale and Todd, after junction, still continue on as a recognisable watercourse for another 40 miles to a swamp 45 miles east of Andado, according to the people of Andado, who should know.

Down the east side of Lake Eyre the existing maps still reproduce the route sketches made by J. W. Lewis in 1874-5. There has been no triangulation in that area. These sketches were necessarily very approximate. The Simpson Desert Expedition passed hurriedly down the side of the lake and did not attempt to map the shores. The arms of the lake were found to be roughly as shown on maps from the north end down to the Cooper, but if the arm at Camp 45 is correct, and it seemed to be so, then the shore of the lake near Camp 47, south of the Cooper, is a good 7½ miles further east than marked. There was a small lake at Camp 48, as shown, but no signs of the big horseshoe lake marked on maps.

The small lakes in the sandridges to the east of the great lake were very interesting. The sandridges, near the middle of the lake and to the south, are

mostly broad, low undulations not more than 40 feet high, without steep crests of live sand, though they were steeper and higher towards the Warburton. Nowhere are they as high and forbidding as in the desert. The lakes, of all sizes and shapes from round ones a mile across to narrow ones 20 miles long, occur sporadically in this undulating sea of sand. The smaller ones are not seen till one comes suddenly on the edge and looks down on the lake floor 60 to 70 feet below, by aneroid measurement. They are like holes scooped out of the sand, or large craters. The floors are absolutely flat sand-free clay surfaces, of a buff colour. They were at the time rather boggy, but during droughts, when the surface is crusty and gypseous, they can be crossed by motor vehicles. In all cases the banks were higher on the southern and western sides, the windward sides, where there was usually live sand in dunes. The remarkable thing is that the lakes persist and do not become filled with drifting sand. It appears that the eddies caused by the depression, together with the smoothness of the floor, keep the floors swept clean of sand. The sand travels north throughout the whole desert, yet it seems to halt and pile up on the windward shores of these lakes. Their origin presents a difficult problem, as it requires a decision as to which was there first, the lakes or the sand, but once dunes have formed on the windward side of the lake their presence would arrest the oncoming sand and they would advance slowly by slumping in the normal way. It seems necessary that the sand must be encroaching on the lakes in this way, and perhaps the leeward shores retreating, but there were no obvious signs of it. The trends of the lakes as mapped seem haphazard, but several of them, together with some of the arms of the great lake, trend south-east at a small angle to the trend of the sandridges, and this suggests that they are protected by crescentic dunes formed by the stronger south-west winds. The lakes towards Poeppel's Corner, like all of those more remote from Lake Eyre, are obviously merely lanes between the sandridges.

The lee shores of arms of Lake Eyre at Camps 43, 44 and 45 all sloped gently upwards northward into the sandridges. The sandridges were very low and the sandy shores not more than 20 feet above the lake floor at Camp 49, but across the neck from this camp along the southern edge of the lake the shores rise to about 50 feet, with broad scattered sandridges in the country to the south. It can be taken that the tops of the sandridges east of the lake are about 70 feet above the lake floor level, and in most parts the gentle undulating ridges themselves are only 20 to 40 feet high, so that the lanes between them are some 40 feet above lake level and the floors of the scattered lakes are probably at about the same level as that of the main lake.

The Cooper, where we crossed it, was in a depression a mile wide crossing the sandridges, but the actual channel was a well-defined sandy bed 50 feet across and a couple of feet deep. The low banks indicated that any floods passing today are small, and the fineness of the sand in the bed and the absence of pebbles and driftwood showed that velocities are low. There were no trees, not even dead ones, in the valley, but only grasses, a condition very different from the box gum flats along this river where the Birdsville track crosses it. No Cooper floods have reached beyond Lake Hope since 1917, but it seemed that local rains must have caused some flow in these lower courses, or the grasses and herbage would have encroached on the bed as they had in the connecting channel between the main lakes.

Heights were determined at every camp, and these are marked on the map. They were calculated from aneroid readings and weather map interpolations, the originals of the weather maps having kindly been made available by the Commonwealth Weather Bureau, Adelaide. The tables used were Nos. 51 and 52 of the Smithsonian Meteorological Tables. The isobars of the weather maps in the central regions are based on widely scattered stations, with an area 800 miles long from Urandangie to Broken Hill and 400 miles wide from Finke to Boulia with-

out any stations at all, so that the expedition stations were mostly 100 to 200 miles from the nearest meteorological station. However, the pressure gradients are small in the inland and interpolations could be relied on in most cases to ·01 of an inch. The diurnal variation at Oodnadatta between 9 a.m. and 3 p.m. was known to be 0·11 inch, and from this figure, by comparison with Adelaide, a full graph of hourly variation was constructed. This gave good results on the western side of the desert, but towards Birdsville the allowance was obviously too great, as shown by observations taken at different times at the same station, afternoon determinations being invariably lower, so that for the greater part of the journey only observations taken at 8.30 a.m., the time for which the weather map was drawn, were used, and the temperature of the intermediate air was taken as that read at the time of observation. As both weather map and aneroid were read to ·01 inch, the maximum error from reading would be 20 feet. The results were remarkably consistent, and all determinations can confidently be relied on to be correct within 50 feet. The calculated height of Abminga was 716 feet, where the railway survey gives 719 feet. Andado Station was at 789 feet, and Camp 4 on the Hale, 634 feet. From there across the desert the fall was fairly uniform down to 136 feet at Kaliduwarry Station on the Mulligan. There was only one rise, to the higher ground between the line of water-courses and claypans at Camp 13 and the Hay River, Camp 14 being 60 feet above Camp 13. The two camps on the Hay, 15 and 16, were at 312 and 306 feet. Annandale Station, on the Mulligan (Camp 21), was 125 feet above the sea, from where the country rose slightly to 149 feet at Birdsville.

The fall down the Diamantina, from Birdsville to the lake, was found to be of the order of 18 inches to the mile.

The height at Camp 41, on the edge of the sandridges near the river, worked out at eight feet, and on the shore of an arm of the lake at the north end, Camp 43, it was 37 feet below sea level. This is in extraordinary agreement with the railway survey's level of 35 feet below in the bed of Stuart's Creek on the south side of Lake Eyre South, too close an agreement on a single reading to be more than a fluke if correct. Camps 44, 45, 46 and 47 were all in the sandridges, from 10 to 40 feet above the lake floor. Camp 48 was on a high ridge at a measured height of 70 feet above the floor of a small lake, making its bed 22 feet below sea level. Camp 49 was 20 feet above the floor of the main lake, giving 35 feet below sea level for the lake bed in the south-eastern corner. Camp 50, in the sandridges near the Clayton entrance, stood at 27 feet above the sea. As mentioned above, these results were very gratifyingly consistent. The railway level at Marree is 155 feet.

IV. METEOROLOGY

Meteorological observations were not carried out very systematically, but enough were taken to give a picture of the weather in the Simpson Desert in the winter months. As the information is meagre, even from the few meteorological stations that do exist round the margins of the area, it is felt that the meteorological log of the expedition is of sufficient interest to warrant publication in full below.

The notes cover a period of ten weeks, from 27 May to 7 August, 1939. In the winter time the track of the anticyclones moves northward towards the centre of the continent and the weather is usually clear and dry. The normal rainfall months of the desert area are January and February, when the anticyclones have receded and the monsoonal depressions invade the country from the north, with rain in the troughs extending south far into and even right across the continent. This particular winter, however, was apparently anomalous, for more than half the average rain fell during the ten weeks of the expedition, the whole area traversed having been inside the 5-inch rainfall line, in the driest part of Australia. The rain was associated with both northerly and southerly depressions.

In general, the weather was either brilliant, with warm days and frosty nights, or overcast with drizzle or light rain, with a very rapid transition from one extreme to the other. Of the 72 days, 52 were clear and sunny and 20 were heavily overcast.

There were six rainy periods. In every case the cloud came up from the west, usually with westerly breezes at first, later veering to the south or south-west. Rain was always associated with a falling barometer. The first rain was very light, merely a few drops in the night, due to a trough extending up from South Australia, where rain was general. The second was also very light, and very local, with the whole area under anticyclonic conditions. The third lasted for five days, during which over 1½ inches fell. This was due to a trough from the north with rains right through the Northern Territory. A week later there was another very light fall, followed four days after by a wet period of six days during which about two inches of rain fell, between 28 June and 4 July. This was also caused by a trough across the continent, with rain first extending up from the south and then down from the north. Three weeks later there was some light precipitation of no consequence.

The inland surface winds rarely exceed 20 miles an hour. Fifteen days were logged as calm. Only light airs were logged from the north, and no winds from the north-east. There were often gentle breezes from the east, but most of the wind blew from between south-south-east and south-west, with some fresh breezes from the south and fresh to strong breezes from the south-west. Few winds came from the west, but north-west winds were very strong round Lake Eyre, where they reached 40 miles an hour on two days. During most of the eight days spent on the east side of Lake Eyre strong westerly winds blew during the day, backing and dying away regularly at sunset. In the summer north-east winds are common, especially on the east side of the desert.

The maximum temperature recorded was 78° F., a chance reading at 2 p.m. on 28 May. On most clear days the temperature would exceed 70° F., but the maximum thermometer was rarely set as the party was moving all day. Twenty-nine settings of the minimum thermometer gave an average of 38·5° F. The highest was 54·8° F. during wet weather on the Hale, and the next was 52·0° F. in the rains at Camp 8. The lowest minimum was 23° F. at Lake Eyre.

Exceptionally heavy dews followed for several nights after rain, but soon ceased.

The mean of the hundred barometric pressure interpolations from weather maps (reduced to sea level), was 30·126 inches. The lowest reading was 29·80 inches at Kalliduwarry, Camp 20, and the highest 30·45 inches near Lake Eyre. The lowest actual aneroid reading was 29·22 inches at Abminga, the highest point, and the highest reading 30·40 at Lake Eyre.

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SIMPSON DESERT EXPEDITION 1939—METEOROLOGICAL LOG

Date 1939	Camp No.	Height Above M.S.L. Ft.	Time Hrs.	Bar. Inches	Air Temp. Deg. F.	Min. Temp. Deg. F.	Wind	Cloud	Remarks
May—									
27	—	574	1500	29·56	74 (Max. 75·5)	38·5 (28 May)	—	—	Charlotte Waters
28	—	496	1400	29·55	78	—	—	—	Mayfield's Swamp
29	—	552	1600	29·40	70	—	—	—	Finke River
29	—	719	1715	29·22	76	—	—	—	Abminga
30	—	552	0900	29·45	57	—	S., 10 m.p.h.	0/10 Clear	Finke River. Very light rain last night, cloud moved up from W.
30	—	489	2100	29·57	58	—		—	Andado Station
31	—	489	0900	—	—	41	S.W.b.S., 20 m.p.h.	0/10 Clear	Andado Station
June—									
1	—	489	0900	29·68	56	40·2	—	5/10 Ac. Sc. on S. horizon	Andado Station
2	—	489	—	—	—	42·8	Calm	0/10 Clear	Andado Station
3	—	489	—	—	—	—	S.W.b.S., 20 m.p.h.	—	Andado Station
4	—	489	0900	29·67	56·8	38·5	S.W.b.S., 20 m.p.h.	0/10 Clear	Andado Station
4	—	586	0900	29·56	56	33·9 (5 June)	S. airs	0/10 Clear	Andado Bore, No. 1
5	1	572	1900	29·55	58	—	Calm	0/10 Clear	—
6	1	572	0730	29·52	36	—	N.W. airs	0/10 Clear	—
6	2	668	2030	29·42	59	—	S.E. airs	0/10 Clear	—
7	2	668	0830	29·43	50	39	N. airs	5/10 Ac. from S.W.	—
8	3	630	1200	29·48	68	54·8	S.E., 10 m.p.h.	9/10 Ac. from W.	Hale River. Overcast, with few drops of rain in early morning
9	3	630	0900	29·57	60	—	S.S.E., 10 m.p.h.	10/10 S. Ac. from S.W	Hale River. 10 points rain during night of 8 June
9	4	634	1500	29·47	70	—	—	1/10 Cc.	Hale River. Cleared during morning. Bright sun
9	4	634	2100	29·52	58	—	—	—	Hale River
10	4	634	0900	29·57	59	—	E., 10 m.p.h.	1/10 Cc.	Hale River
11	5	671	0830	29·48	43	30·3	—	1/10 Ci. from W.	—
11	6	602	1700	29·96	66	—	—	8/10 Ci. from W.	—
12	6	602	0900	29·55	56	—	E., 15 m.p.h.	9/10 Ac. from W.	—
12	7	495	1800	29·64	63	—	S.S.E., 10 m.p.h.	10/10 As. from W.	—
13	7	495	0900	29·67	56	—	S. breeze	10/10 Ni. As.	Very light rain last night, 3 pts.
13	8	456	2000	29·77	64	—	—	—	—
14	8	456	1100	29·58	59	—	S-S.S.E.	10/10 Ni.	20 pts. rain during last night
14	8	456	2100	29·48	50?	—	—	10/10 Ni from N.E.	Light drizzle all day; rain all night
15	8	456	1400	29·44	63	—	N. airs	10/10 Ni.	Light rain and mist continue—1 inch rain since 1800 hrs. on 14th measured. Wind has backed through E. to N.

SIMPSON DESERT EXPEDITION 1939—METEOROLOGICAL LOG (Continued)

Date 1939	Camp No.	Height Above M.S.L. Ft.	Time Hrs.	Bar. Inches	Air Temp. Deg. F.	Min. Temp. Deg. F.	Wind	Cloud	Remarks
June—									
15	8	456	1600	29·42	60?	—	S.W., 20 m.p.h.	9/10 Sc. from S.W.	Cloud breaking. Rain ceased
16	8	456	0900	29·53	58	—	S., 20 m.p.h.	10/10 Sc.	Overcast all day
17	8	456	0900	29·50	56	52	S.W. breeze	8/10 Cu. from S.W.	Showers during last night—now clearing
17	9	435	2000	29·54	61	—	Var.	10/10 Cu.	Cloud motionless. N. airs at 7 p.m., S. at 8 p.m.
18	9	435	0900	29·57	59	—	N. breeze	0/10 Clear	Clear and sunny
18	10	391	1900	29·60	62	—	———	———	———
19	10	391	0900	29·73	62	49	S. breeze	0/10 Fr. Cu. from S.	———
19	11	360	1800	29·70	61	—	———	———	———
20	11	360	0900	29·73	52	37	N. airs	0/10 Clear	Heavy dew last three nights
20	12	345	1730	29·72	60?	—	S.S.E. breeze	0/10 Clear	———
21	12	345	0800	29·71	50	37·2	———	———	———
21	13	335	1500	29·67	68	—	———	———	———
21	13	335	1900	29·67	55	—	N.W. airs	0/10 Clear	N.W. airs
22	13	335	0800	29·65	50	37·4	N. airs	0/10 Clear	———
22	14	395	2100	29·64	50	—	———	0/10 Clear	———
23	14	395	0730	29·67	50?	38·8	———	———	———
23	15	312	1500	29·69	70?	—	———	0/10 Clear	———
23	15	312	1900	29·63	58	—	———	———	Hay River
24	16	306	1400	29·62	74	—	N. light	0/10 Ci. in W.	Hay River. Frost last night, first since entering desert
24	16	306	1900	29·59	56	—	———	———	Hay River
25	16	306	0800	—	—	47	N.W. airs	8/10 Sc. from W.	Hay River. Few drops of rain last night
25	16	306	0900	29·58	64	—	———	———	Hay River
25	17	263	1800	29·596	67	—	Calm	0/10 Clear	Queensland Border. Clear. During afternoon, wind changed to W. at 20 m.p.h., cloud to A.Cu., then cleared.
26	17	263	0800	29·72	53	32·5	Calm	0/10 Clear	Queensland Border. Clear and calm
26	18	196	1700	29·78	72	—	Calm	0/10 Clear	Breezes during day from N.W. to S.W.
27	18	196	0800	29·83	49	30·8	Calm	0/10 Clear	Calm and clear
27	19	168	1700	29·82	73	—	Calm	1/10 Ci. from W.	Cloud came up from W. during night. Ci.Cu. moving rapidly at 2200 hours
28	19	168	0800	29·796	58	44·5	S.E. airs	10/10 As.	———
28	20	136	2300	29·65	62	—	S.W., 15 m.p.h.	10/10 Ni. from W.	Mulligan River. Wind N.W. during day, changed to S.W. at night with light rain (¼ inch)
29	20	136	—	—	—	—	W	10/10 Ni.	Mulligan River. Light rain all day
30	20	136	—	—	—	—	———	———	Mulligan River. Clear, sunny day. A.Cu. came up from W. in evening

SIMPSON DESERT EXPEDITION 1939—METEOROLOGICAL LOG (Continued)

Date 1939	Camp No.	Height Above M.S.L. Ft.	Time Hrs.	Bar. Inches	Air Temp. Deg.F.	Min. Temp. Deg.F.	Wind	Cloud	Remarks
July—									
1	20	136	0900	29·846	58	—	Var.	10/10 Sc.	Mulligan River. Light rain in early morning; stopped at 0830 hours
1	21	125	2000	29·89	60?	—	———	10/10 Ni.	Mulligan River. Rain began at 1500 hours, and still raining
2	21	125	0900	29·87	54	—	———	10/10 Ni.	Mulligan River. Still raining, ½ inch in last 24 hours
2	21	125	1600	—	—	—	E. 15 m.p.h.	10/10 Ni. from E.	Mulligan River. Still raining
2	21	125	1800	—	—	—	———	10/10 Ni	Mulligan River. Still raining. 60 pts. since 0900 hrs.
3	21	125	0900	29·73	56	—	E. airs	10/10 Ni	Mulligan River. Light rain; 54 pts since 1800 hours. Mists now clearing
3	22	140	2100	29·78	50	—	———	———	Light rain on and off all day
4	22	140	0900	29·91	50	—	S.W., 20 m.p.h.	3/10 Sc. from S.W.	Light showers in morning. Clearing
4	23	144	1800	29·86	52	—	S.W., 25 m.p.h.	10/10 Sc. from S.W.	Overcast all day; no rain. Bitter wind. Water lying about everywhere. Sky cleared by 2000 hours. Clear all night
5	23	144	0800	29·91	49	—	S.	0/10 Clear	———
5	24	108	1600	29·92	56	—	S., 15 m.p.h.	10/10 Sc.	Clear all morning. Fr.Cu. at noon gradually increased
6	24	108	0800	29·98	53	—	Calm	10/10 Sc.	Few drops of rain early last evening. Overcast all day
7	25	149	—	—	—	—	———	———	Birdsville. Sky cleared during evening
8	25	149	—	—	—	—	———	———	Birdsville. Clear, calm day
9	25	149	0900	29·90	56	38 (Max 66·2)	———	———	Birdsville
9	25	149	1900	29·77	55	—	———	———	Birdsville
10	25	149	0800	29·78	50	43 (Max. 67·5)	S.W., 10 m.p.h.	0/10 Clear	Birdsville. During day strong W. breeze to 30 m.p.h., with some cloud
11	25	149	0300	—	—	—	S.W.	0/10 Clear	Birdsville
11	26	120	1900	—	—	—	S.S.W., light breeze	0/10 Clear	S.S.W. wind, 20 m.p.h. all day, till 1800 hours, with 9/10 S.Cu. cloud
12	26	120	0800	30·096	52	—	S., 5 m.p.h.	0/10 Clear	———
12	27	105	1600	30·096	—	—	———	———	———
13	27	105	0800	30·14	48	—	Calm	0/10 Clear	———
14	28	98	0900	30·12	56	—	E., light breeze	2/10 Cc. Ac. to W.	Andrewilla Waterhole
15	28	98	0800	30·02	48	—	Calm	0/10 Clear	Andrewilla Waterhole
16	29	71	0800	29·96	52	—	E. breezes	0/10 Clear	———
17	30	—	0800	29·84	45	34·5	N. breezes	0/10 Clear	Heavy dews all through desert, but much lighter last night, and not conspicuous for rest of journey

Fig. 1
The end of the Todd River, from Poodnitera Hill.

Fig. 2
Allua Soak, Hale River, Camp 4.

Fig. 1
Typical Simpson Desert Sandridge, near Andado Station.

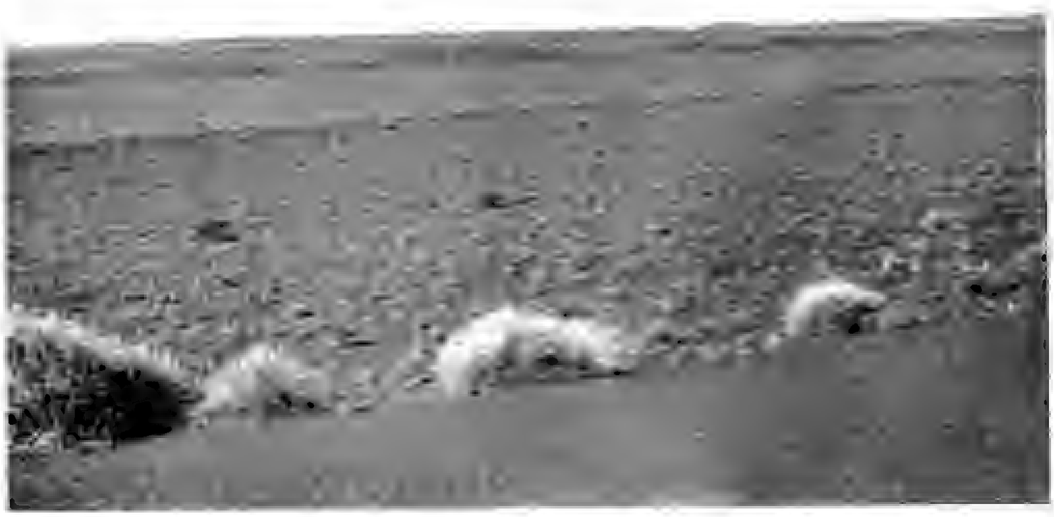


Fig. 2
The Desert, between Camps 9 and 10.

Fig. 1
A Claypan in the middle of the Desert, between Camps 11 and 12.

Fig. 2
The Expedition descending a Sandridge near the Queensland Border, between Camps 17 and 18.

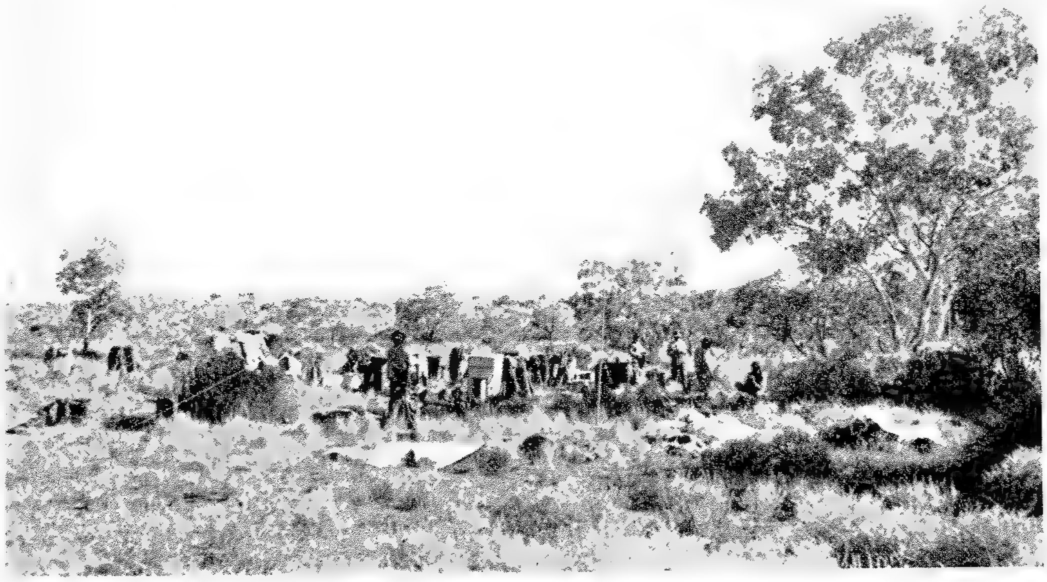


Fig. 1
Camp 15, in the Hay River Valley.

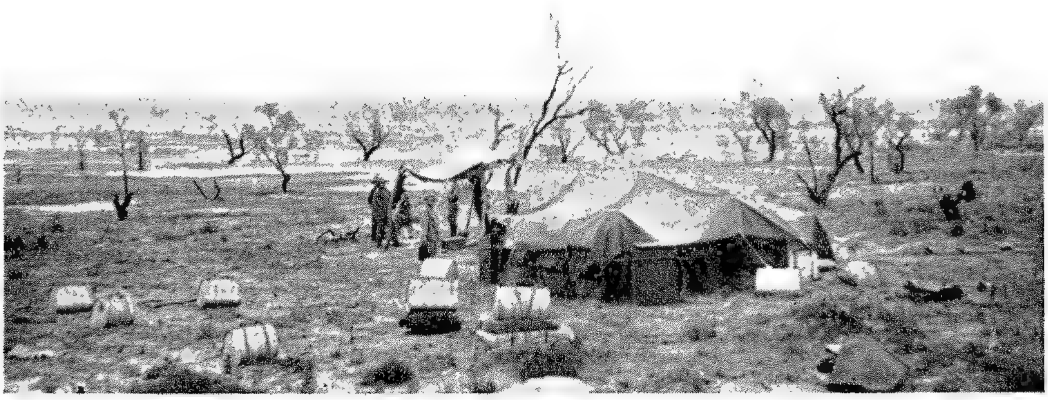
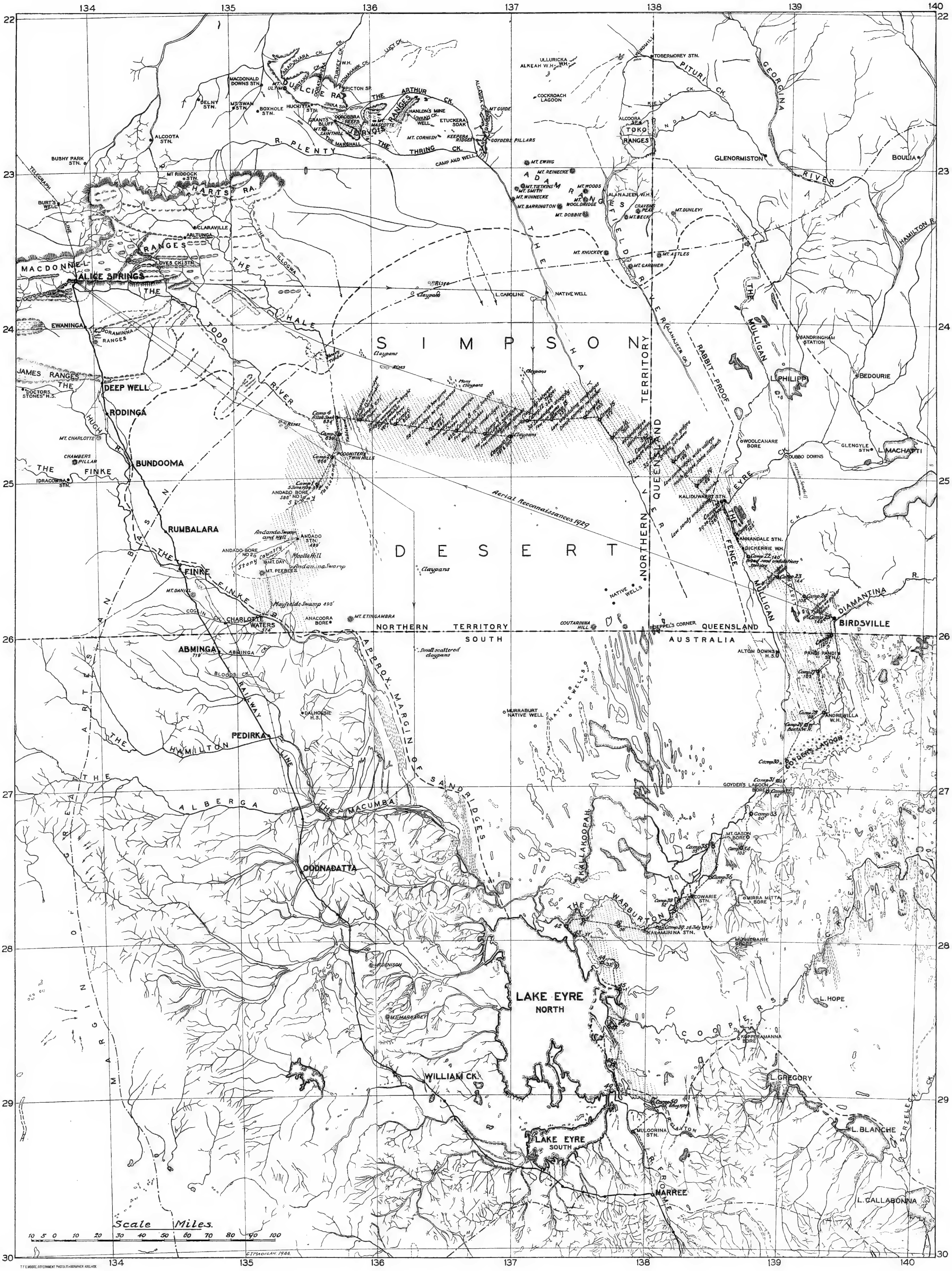


Fig. 2
Camp 21, on the River Mulligan.

Fig. 1
Tree blazed at Camp 16, River Hay

Fig. 2
Lake Eyre, at the middle of the east side.



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SIMPSON DESERT EXPEDITION 1939—METEOROLOGICAL LOG (Continued)

Date 1939	Camp No.	Height Above M.S.L. Ft.	Time Hrs.	Bar. Inches	Air Temp. Deg. F.	Min. Temp. Deg. F.	Wind	Cloud	Remarks
July—									
18	31	53	0900	30·18	54	—	S., 10 m.p.h.	0/10 Clear	Yesterday wind blew S.W. to S. at 20 m.p.h.
19	32	62	0900	30·23	54	—	S., 10 m.p.h.	0/10 Clear	Goyder's Lagoon Bore. During day some Fr.Cu. formed but cleared in the evening. S. breeze all day
20	33	50	0800	30·246	50	—	S.E. airs	2/10 Ci. from W.	S.E. wind all day. Gradually became overcast
21	34	103	0900	30·14	56	—	E., 10 m.p.h.	10/10 Ac.	Mount Gason
22	34	103	0800	30·12	54	—	Calm, E. airs	10/10 As.	Mount Gason. Few drops rain last night and at present. Very light misty rain all day, cleared during night
23	35	35	0800	30·22	50	—	Calm	0/10 Cu. in S.E.	—
24	36	26	0800	30·30	48	—	Calm	0/10 Clear	—
25	37	—	1100	30·35	66	—	E. breezes	0/10 Ci. on N. hor.	Cowarie Station
26	38	52	0800	30·39	48	—	E., 10 m.p.h.	0/10 Clear	On sandridge
27	39	26	0800	30·40	44	29·4	E., 10 m.p.h.	0/10 Clear	On sandridge
28	40	36	0800	30·22	40	—	E. breezes	0/10 Clear	On sandridge
29	41	8	0800	30·12	47	32	E. breezes	0/10 Clear	River flat
30	42	—	0800	—	—	41	S.W., 30 m.p.h.	—	Became overcast during last night with few drops of rain; cloud from N. cleared during morning, with wind W to S.W. 30 m.p.h.
31	43	−37	0800	30·27	52	—	Calm	0/10 Clear, Ac. in N.W.	Shore Lake Eyre
31	44	−23	1900	30·17	54	—	—	—	On sandridge. During day W to S. winds, dropping to calm in the evening; clear
Aug.—									
1	44	−23	0800	30·17	52	—	S.W. breeze	10/10 Sc.	Bitter S. wind all afternoon, 25 m.p.h. Sky gradually cleared. Clear and calm at 1900 hours
2	45	−1	0800	30·24	47·5	36·4	Calm	0/10 Clear	On sandridge. Bitter S. wind 0900 to 1800 hrs., when it dropped
3	46	+8	0800	30·24	44	—	S. breeze	0/10 Clear	On sandridge
4	47	+8	0800	30·11	38	23	N. airs	0/10 Clear	On sandridge. Wind rose during day to 40 m.p.h., N.N.W. N. wind all night; dying down
5	48	+18	0830	29·83	54	32·5	N.N.W., 25 m.p.h.	5/10 Ac. from W.	On sandridge. Strong wind all day from N.N.W., backed to W. in evening, died down at 2000 hrs., when sky cleared
6	49	−15	0800	29·896	51	—	W.N.W., 20 m.p.h.	0/10 Clear	Near shore. Strong W.N.W. wind all day, 30 m.p.h. Died down at 1800 hrs. Cloud during day, cleared at night
7	50	+27	0800	28·93	50	43·7	W. breeze	0/10 Clear	In sandridges

A CONTRIBUTION TO THE ECOLOGY OF CALANDRA ORYZAE L. AND RHIZOPERTHA DOMINICA FAB. (COLEOPTERA) IN STORED WHEAT

BY L. C. BIRCH, WAITE AGRICULTURAL RESEARCH INSTITUTE, UNIVERSITY OF ADELAIDE (READ 14 JUNE 1945)

Summary

The storage, for unusually long periods, of large quantities of wheat in Australia directed attention early in the war to the possibility of infestation of the grain by insects. It soon became apparent that the two most important primary pests of wheat in Australia were *Calandra oryzae* L. and *Rhizopertha dominica* Fab. (Gay and Ratcliffe 1941). It was appreciated that the extent to which infestations of these insects would develop was dependent upon the temperature and moisture content of the wheat in storage. And the information that was then known of the effect of temperature and moisture on the biology of the two species was summarised by Davidson (1940) and Ratcliffe, Gay and Fitzgerald (1940). It was evident, however, that the knowledge available was scanty and quite inadequate. The writer, therefore, set out to determine as precisely as possible the effect of temperature and moisture on the rate of multiplication of the two species concerned, and to find out the ocnditions under which they could not increase in numbers. For this purpose, it was necessary to determine by experiments the biotic constants for these insects. The biotic constyants describe quantitatively the rates of egg-laying and the rates of development and survival of the different stages of the insects under various conditions of temperature and moisture (*c.f.* Chapman and Baird 1934). The experimental work on the results of which the biotic constants were determined has been described in a number of papers given in the list of references. The results of that work are further discussed in the present paper.

A CONTRIBUTION TO THE ECOLOGY OF CALANDRA ORYZAE L. AND RHIZOPERTHA DOMINICA FAB. (COLEOPTERA) IN STORED WHEAT

By L. C. Birch
Waite Agricultural Research Institute, University of Adelaide

[Read 14 June 1945]

Plates X and XI

I. Introduction

The storage, for unusually long periods, of large quantities of wheat in Australia directed attention early in the war to the possibility of infestation of the grain by insects. It soon became apparent that the two most important primary pests of wheat in Australia were *Calandra oryzae* L. and *Rhizopertha dominica* Fab. (Gay and Ratcliffe 1941). It was appreciated that the extent to which infestations of these insects would develop was dependent upon the temperature and moisture content of the wheat in storage. And the information that was then known of the effect of temperature and moisture on the biology of the two species was summarised by Davidson (1940) and Ratcliffe, Gay and Fitzgerald (1940). It was evident, however, that the knowledge available was scanty and quite inadequate. The writer, therefore, set out to determine as precisely as possible the effect of temperature and moisture on the rate of multiplication of the two species concerned, and to find out the conditions under which they could not increase in numbers. For this purpose it was necessary to determine by experiments the biotic constants for these insects. The biotic constants describe quantitatively the rates of egg-laying and the rates of development and survival of the different stages of the insects under various conditions of temperature and moisture (*c.f.* Chapman and Baird 1934). The experimental work on the results of which the biotic constants were determined has been described in a number of papers given in the list of references. The results of that work are further discussed in the present paper.

In the course of the investigations, it was found that there were at least two strains of *C. oryzae*, a "large strain" and a "small strain". Besides differing in size, the two strains have different biotic constants. The "large strain" has only been found occurring naturally in maize in Australia, although it breeds readily in wheat in laboratory cultures. Except where otherwise stated, all references in this paper are to the "small strain."

II. The Biotic Constants of Calandra oryzae

(*i*) *The rate of mortality and speed of development of the immature stages.*

The effect of dryness and unfavourable temperatures on the development of *C. oryzae* varies with the different stages of the insect. The eggs are the stage in the life cycle least susceptible to adverse affects of dryness and high temperature. They can develop and hatch under conditions which are lethal to other stages. The eggs hatched, for example, when the relative humidity of the air was as low as 27%; wheat at this relative humidity has a moisture content of 8%.[1] The larvae, on the other hand, were unable to survive when the wheat had a moisture content less than 10·5%. And in wheat of 10·5% moisture content

[1] The values for moisture content of wheat given in this paper were determined by drying the wheat for 72 hours at 105° C., the moisture content was then expressed as the percentage loss of the original weight.

the mortality exceeded 75% at all temperatures. The first larval instar was more susceptible than later instars. If the conditions were sufficiently favourable for the survival of the first instar, then there was practically a hundred per cent. survival of the later instars and pupae.

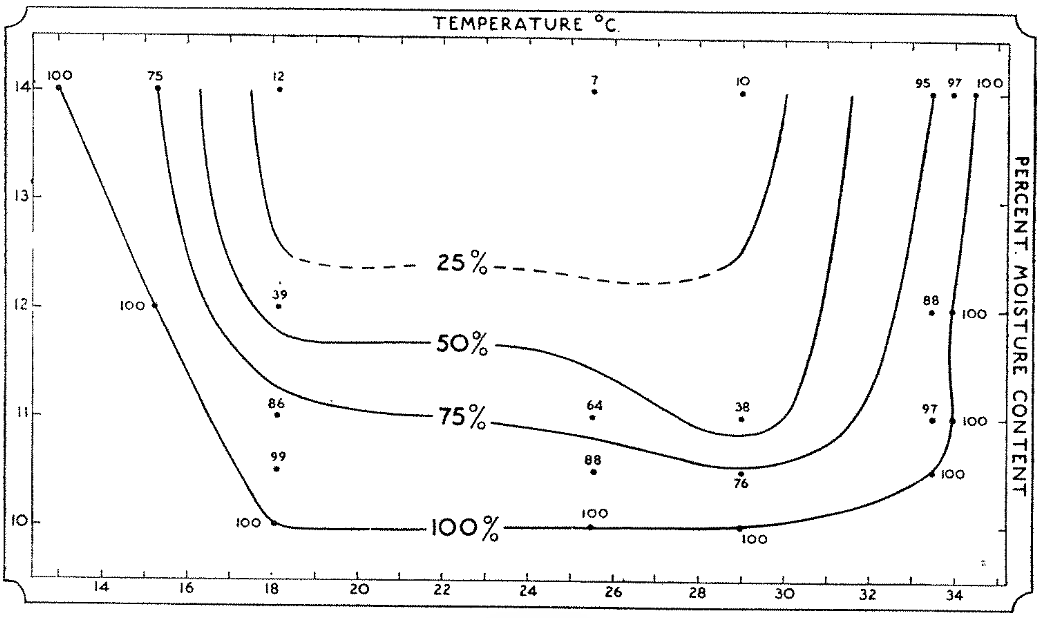


Fig. 1
Showing lines of equal mortality for the small strain of *Calandra oryzae* in development from the egg to the adult stage. The small figures are the experimental values.

Figure 1 shows the mortality in development from egg to adult, for the complete range of temperature and moisture within which there is any survival of insects at all. Lines of equal mortality have been interpolated from the experimental values, which are shown in small figures. In wheat of 14% moisture content some insects were able to develop from egg to adult at any temperature

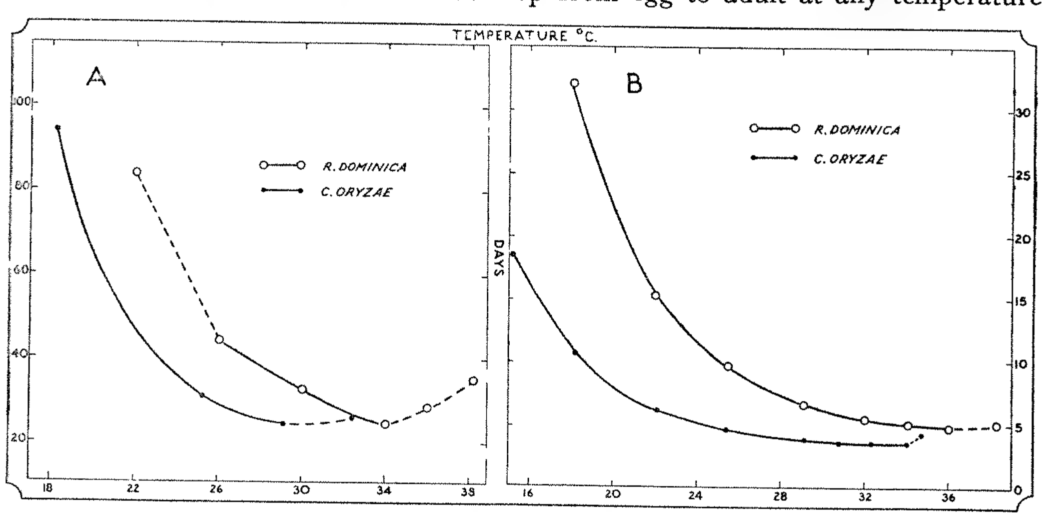


Fig. 2
Showing the time required for the development of *C. oryzae* and *R. dominica* in wheat of 14% moisture content at different temperatures.
A, "Egg to Adult". B, "The Egg Stage".

between 15·° C. and 34° C. In wheat drier than 14% moisture content the range of temperature within which any insects survived was smaller and the mortality at any particular temperature was higher. The temperature range within which there was any survival in wheat of 10·5% moisture content, for example, was 18° C. to 30° C.; the higher mortality can be seen from the figure.

The time taken for the development of the egg at various temperatures under favourable conditions of moisture is shown in fig. 2 B, and that for the development from egg to adult in grain of 14% moisture content is shown in fig. 2 A. The egg develops in the shortest time at 32·3° C. taking 3·3 days; but the larva develops fastest at a lower temperature, namely, 29° C. At this temperature the insect develops from egg to adult in 25 days; the adult then remains a few days inside the grain before it bores its way out. Development from egg to adult was longest at 15·2° C., taking over seven months; at this low temperature the mortality was 75% in grain of 14% moisture content.

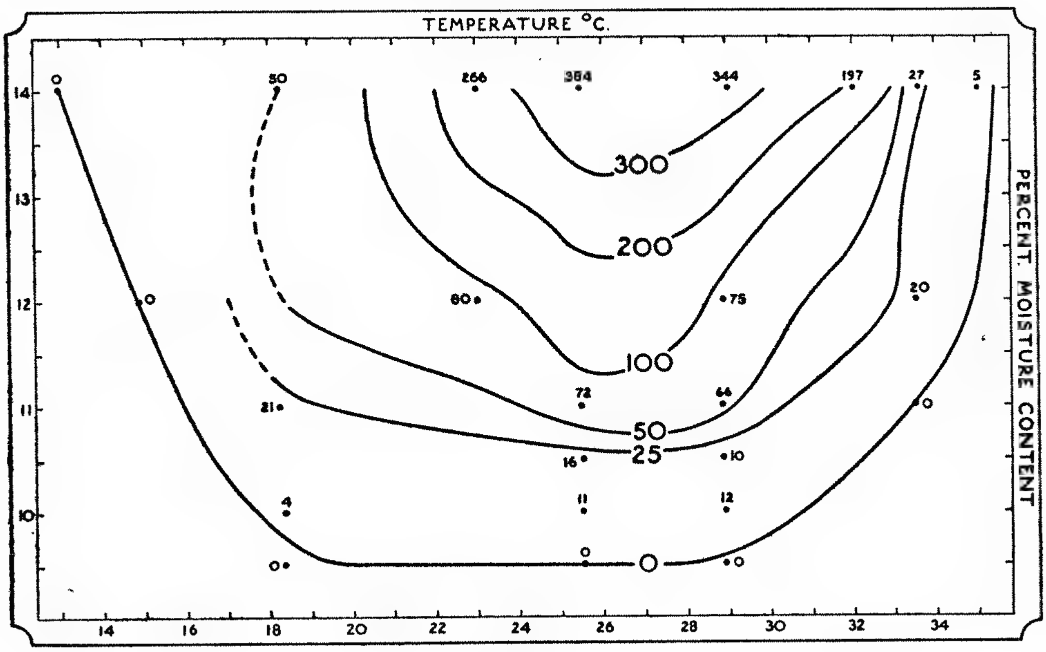


Fig. 3

Showing lines of equal egg production for the small strain of *Calandra oryzae*. Small figures are experimental values.

Of the total time taken to develop from egg to adult, the pupa occupied about 25% and the prepupa 6%; most of the time (about 55%) was spent in the feeding larval stage.

When wheat was drier than 14% moisture content, development was slightly longer than the times shown in fig. 2. In wheat of 11% moisture content, for example, *C. oryzae* took 2·4 days longer to complete development at 29° C.

(*ii*) *The rate of oviposition.*

C. oryzae begins to lay eggs within the first few days of the female boring its way out of the grain, and it reaches the maximum rate of egg-laying at the end of the first or second week, depending on the temperature. The females then continue laying eggs for about three months. The rate at which eggs were laid during this period did not remain constant for any length of time except at temperatures of 23° C. and lower. At temperatures above 23° C., the rate at which

eggs were laid gradually fell off after the peak rate had been reached in the first two weeks.

The total number of eggs laid and the speed with which they are laid depends not only upon temperature and the moisture of the grain, but also upon the density of the insects in the grain. At a density of one insect in 50 grains for example, the rate of egg-laying was maintained at a higher level, more especially after the first eight weeks of egg-laying, as compared with the rate of egg-laying at a density of one insect in ten grains. This resulted in a greater number of eggs being laid at the lower density. In an infestation of stored wheat, the density of the insects would, of course, change as the infestation developed. Little has yet been pub-

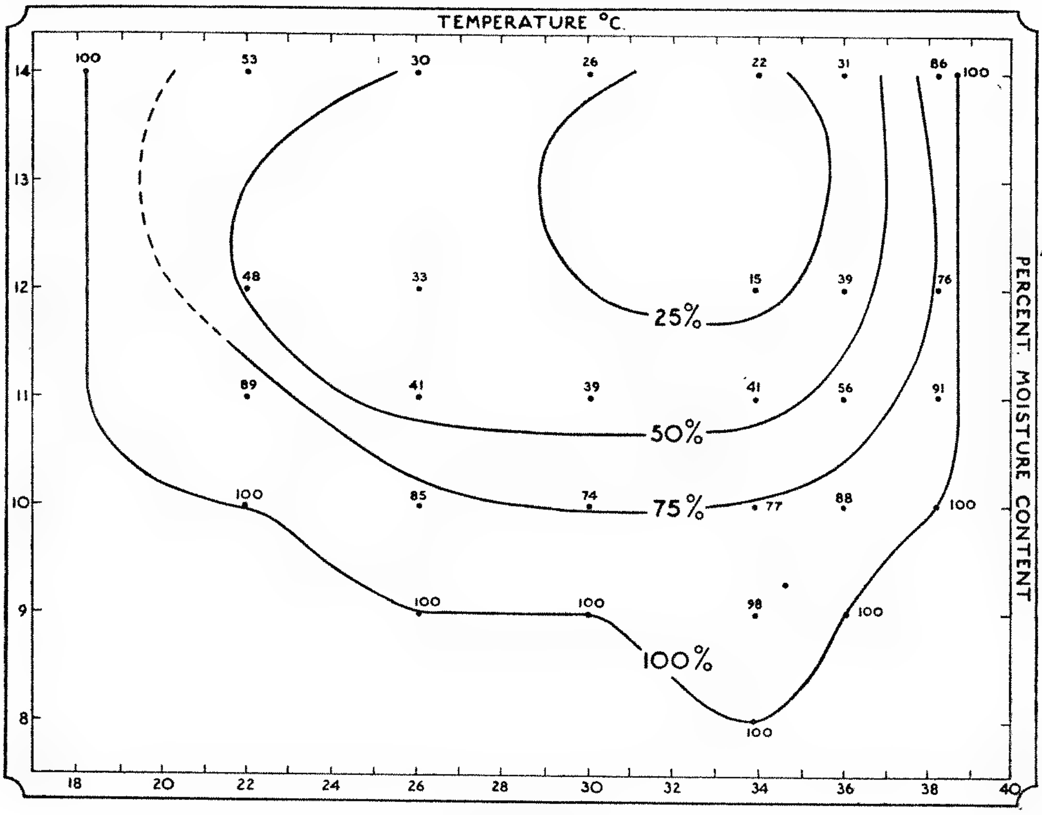


Fig. 4

Showing lines of equal mortality of *Rhizopertha dominica* in development from the egg to the adult stage. Small figures are experimental values.

lished, however, on the way in which density changes and its relation to the movements of insects in the wheat.

The total numbers of eggs laid under different conditions of temperature and moisture (at a density of one insect in 10 grains) are shown in fig. 3. Lines of equal egg production have been interpolated from the experimental data (shown in small figures). The most favourable conditions for egg-laying are shown by the isopleth for 300, *i.e., C. oryzae* lays 300 or more eggs at temperatures between 24° C. and 30° C in wheat having moisture contents between 13% and 14%. The maximum number of 384 eggs was laid in wheat of 14% moisture content at 25·5° C. Eggs were laid at the greatest rate at temperatures between 25·5° C. and 29° C., the actual temperature depending upon the density of the insects in the grain.

The combinations of temperature and moisture, which are so unfavourable that no eggs are laid, are shown by the isopleth for zero in fig. 3. When moisture

is not the limiting factor, 15° C. and 35° C. are the lowest and highest temperatures at which any eggs are laid. When grain is drier than 14% moisture content, the range of temperature within which any eggs are laid is smaller. *C. oryzae* is only able to lay eggs within a very narrow range of moisture content. Even in wheat of 12% moisture content the number of eggs laid is one-quarter of the number laid in wheat of 14% moisture content. And in wheat of 10% moisture content, the driest in which any eggs are laid, no more than a dozen eggs were laid at any temperature.

III. The Biotic Constants of Rhizopertha dominica

(i) The rate of mortality and speed of development of the immature stages.

All the stages of *R. dominica* were able to survive under drier conditions and at higher temperatures than the various stages of *C. oryzae*. As with *C. oryzae*, the eggs were the most resistant of all the stages to the harmful effects of dryness and high temperature. Some eggs (9%) hatched at the high temperature of 39° C., and some were able to hatch in an atmosphere of about zero relative humidity (*i.e.*, over concentrated sulphuric acid). The cuticle of the egg is apparently sufficiently impermeable to prevent much loss of moisture from the egg in dry atmospheres. The great resistance of eggs of *R. dominica* as compared with *C. oryzae* is correlated with the particular micro-environments in which the eggs develop. The eggs of *C. oryzae* are laid inside the grain and so are protected from the sudden changes of temperature and humidity of the outside atmosphere; those of *R. dominica,* on the other hand, are laid outside the grain, where they are subject to more severe desiccating influences.

When the first stage larva hatches from the egg it proceeds to find its way into the grain. If the grain is damaged, it enters through cracks in the grain. In sound grain the larvae generally enter at the embryo end where the covering testa is loose. This freely-wandering larva is the weakest link in the chain of the life cycle; it is more easily killed by dryness and high temperature than any other stage. Under any combination of temperature and moisture, a large proportion of the first stage larvae perish without entering the grain. When, however, entry into the grain is facilitated, as when the grain is cracked and damaged, a much larger number of first stage larvae enter and become established in the grain. Quite a high proportion of the larvae that succeed in entering both damaged and undamaged grain, die in the first instar; the hazards of entering the grain apparently weaken these larvae. It was also found that *R. dominica* was able to develop in drier grain when the grain was damaged; this was due to the greater number of first stage larvae which were able to enter the grain without dying. In wheat of 9% moisture content, for example, some insects were able to complete their development from egg to adult at any temperature between 26° C. and 36° C., when the grain was damaged; but in sound grain of 9% moisture content, the only temperature at which any insects were able to survive was 34° C. Wheat of 9% moisture content was the driest in which any insects were able to survive.

Fig. 4 shows the mortality in development from the egg to adult for the complete range of temperature and moisture within which any insects were able to survive. Reduction of moisture content below 14% did not have anything like the same effect on *R. dominica* as it had with *C. oryzae*. There is no significant difference between the mortality of insects developing in wheat of 14% moisture content and 12% moisture content (compare with fig. 1). Not until the moisture content was reduced below 11% did mortality increase greatly. At most temperatures the mortality in wheat of 10% moisture content was about twice as high as the mortality at 11%.

The isopleths of equal mortality in fig. 4 tend to lie concentrically around the intersection of the ordinate for 14% moisture content and the abscissa for 34° C.;

this is because mortality was less at 34° C. in wheat of all moisture contents and least in wheat of 14% moisture content. It is associated with the facts that development takes place in the shortest time at 34° C. and temperatures above 34° C. begin to exert a direct harmful effect, until development is prevented altogether at 39° C. The highest temperature at which any insects developed from egg to adult was 38·6° C.; at this temperature 17% survived when the grain was damaged.

Fig. 2 A and 2 B show the time taken by the egg and the other stages to complete their development in grain of 14% moisture content. The development from egg to adult took place in the shortest time at 34° C. (24·7 days), and the longest time at 22° C. (84 days). Most of the time was spent in the feeding larval stages; the egg stage occupied about 16% of the total time, whilst the prepupal and pupal stages together occupied 15% of the total time. In comparing

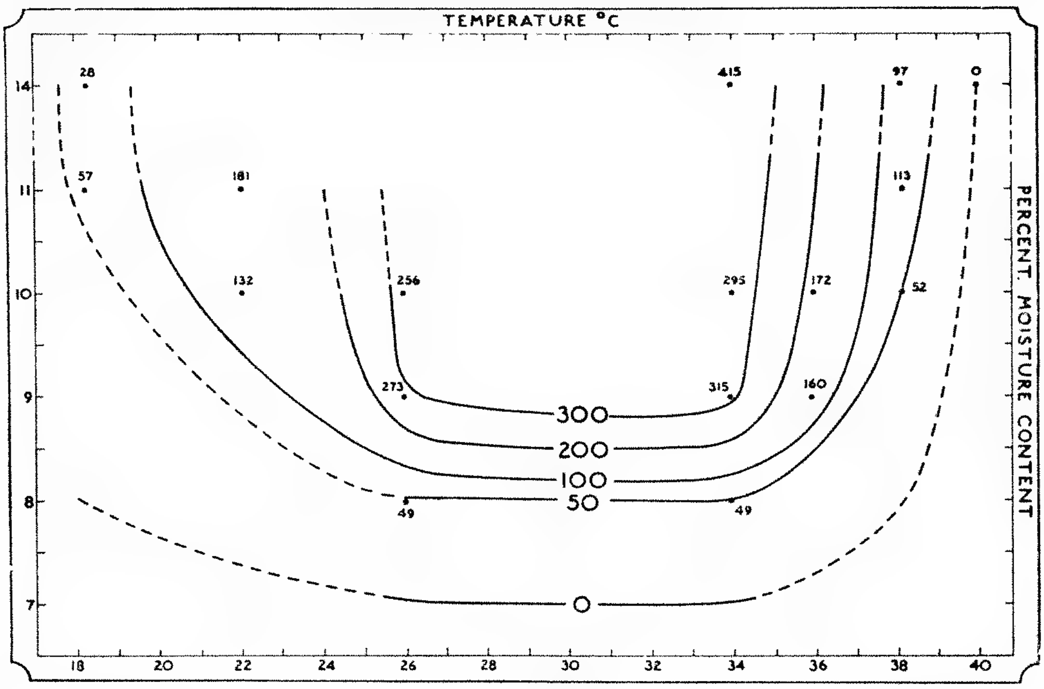


Fig. 5
Showing lines of equal egg production for *Rhizopertha dominica*.
Small figures are experimental values.

fig. 2 A and 2 B, it will be seen that the eggs developed fastest at a higher temperature (36° C.) than the temperature (34° C.) at which the other stages developed fastest.

Fig. 2 A shows that *R. dominica* took longer to develop than *C. oryzae* at all temperatures except at 32·2° C. At 32·2° C. the two species developed from egg to adult in 26 days. At higher temperatures *R. dominica* is able to develop, whereas *C. oryzae* ceases at 34° C.

(*ii*) *The rate of Oviposition.*

Females begin laying eggs within the first few days of their emergence from the grain, and if plenty of food is available, the maximum rate of egg-laying is reached in the first fortnight. They continue laying up to four months under favourable conditions. It was found that the number of eggs laid was dependent not only upon temperature, moisture and the density of the insects, but varied

according to whether the insects had access to damaged grains for food. When they did not have access to damaged grains, they only laid eggs at one-eighth of the normal rate. It would seem that the adults have greater difficulty in feeding in sound grain than in grain which has been damaged. The cracks in damaged grain were favourite sites for the deposition of eggs, very few eggs were laid loose; in sound grain they were mainly deposited in the crease or under the loose testa of the grain.

At all temperatures below 34° C. the rate at which eggs were laid fluctuated widely over an average value for most of the life of the insect, without reaching any one definite peak. At 34° C., and at higher temperatures, a peak value for rate of egg-laying was reached in the first fortnight, and after that it gradually fell until oviposition ceased altogether.

Fig. 5 shows the number of eggs laid in wheat of various moisture contents at different temperatures. The greatest number of eggs (415) were laid at 34° C. in wheat of 14% moisture content. In wheat of 14% moisture content, oviposition ceased at a temperature between 15° C. and 18° C. and at temperatures higher than 39° C. Dryness had much less influence in reducing the number of eggs laid by *R. dominica* compared with the effect of dryness on the egg-laying of *C. oryzae*. The number of eggs laid did not fall off markedly until the moisture content of the wheat was below 9% (*c.f.* fig. 5). Wheat of 8% moisture content was the driest in which any eggs were laid.

IV. The Multiplication of C. oryzae and R. dominica

(*i*) *The multiplication in one generation.*

The development of an infestation of insects in wheat is dependent upon the conditions being sufficiently favourable for the numbers to increase from one generation to the next. The actual number of insects which will be produced by a single pair in one generation will depend upon the value of the biotic constants for egg laying and the mortality in the development from the egg to the adult insect. The values of these constants have been given in preceding sections of this paper (*c.f.* fig. 1, 3, 4 and 5). They have now been combined in the following formula to give the multiplication of insects in one generation:

$$\text{The multiplication in one generation} = \text{Total number of eggs laid per female} \times \frac{\text{per cent. of eggs giving rise to adult insects}}{2 \times 100}$$

The formula is based on a sex ration of unity. It has been shown previously that the number of males and females arising from a random selection of eggs of both *C. oryzae* and *R. dominica* is the same.

Table I

Showing the multiplication of the small strain of *C. oryzae* in one generation in wheat of various moisture contents at different temperatures.

Per cent. Moisture Content	Temperature °C. 13	15·2	18·2	25·5	30	32	33·5	34	35
10	—	—	—	0	0	—	—	—	—
10·5	—	—	0	1	1·2	0	—	—	—
11	—	0	1·5	13	21	0	0	—	—
12	—	0	—	—	—	—	1·2	0	—
14	0	1 (2) (approx.)	1+	179	155	80	4	0·1	0

(2) A population could maintain its numbers from one generation to the next at 15° C. in wheat of 14% moisture content, but each generation would take a year to complete.

TABLE II

Showing the multiplication of *R. dominica* in one generation in wheat of various moisture contents at different temperatures.

Per cent. Moisture Content		Temperature °C. 18·3	22·0	26·0	34·0	36·0	38·2	39·2
8	sound grain	—	—	—	0	—	—	—
	damaged [8]	—	—	0	0	0	—	—
9	sound	—	—	0	3	0	—	—
	damaged	—	0	53	36	11	—	—
10	sound	—	0	19	34	10	0	—
	damaged	—	3	—	—	—	2	—
11	sound	—	11	—	—	—	5	—
	damaged	—	—	—	—	—	—	—
14	sound	0	—	—	162	—	7	0
	damaged	0	—	—	—	—	37	0

Plates X and XI show the data of Tables I and II respectively in the form of three-dimensional graphs. The points on the graphs where the lines rise from the basal grid indicate the conditions under which the insects can increase in numbers from one generation to the next, *i.e.*, where the values of the vertical ordinate exceed unity. Under the most favourable conditions the two species have about the same potential rate of increase, *i.e.*, in wheat of 14% moisture content *C. oryzae* can increase in numbers 179 times in one generation at 25·5° C.; at 34° C. *R. dominica* can increase in numbers 162 times.

Wheat of 10% and 11% moisture content is within the favourable zone for the multiplication of *R. dominica* over a wide range of temperatures, but these moisture contents are near the lower limit of *C. oryzae*. This striking difference is chiefly due to the fact that *R. dominica* maintains a high rate of egg-laying in wheat of 10% and 11% moisture content, whereas the number of eggs laid by *C. oryzae* is greatly reduced at moisture contents below 13% (*c.f.* fig. 3 and 5). Although *R. dominica* has a multiplication rate of 10 to 34 in wheat of 10% moisture content between 26° C. and 36° C. (depending upon the temperature), the mortality in development from egg to adult is high, varying from 74 to 88 (depending upon the temperature). This shows that under conditions in which the insect can multiply rapidly there can also be high mortality of the immature stages.

The ranges of temperature at different moisture contents of wheat within which the two species can maintain or increase the size of the population are summarised from Tables 1 and 2 in Table III.

TABLE III

Showing the range of temperature within which a population can maintain or increase its size from one generation to the next.

Per cent. moisture content	Temperature °C. *Calandra oryzae*	*Rhizopertha dominica*
8·0	0	0
9·0	0	26·0 – 36·0
10·0	0	22·0 – 38·2
10·5	25·5 – 30·0	—
11·0	18·2 – 30·0	22·0 – 38·2
12·0	18·2 – 33·5	—
14·0	15·2 – 33·5	22·0 – 38·2

[8] The grain was damaged by making two oblique scalpel cuts. The figures for the number of eggs laid, used in calculating the two sets of figures above, were obtained from insects which had damaged grain to feed on.

(*ii*) *The rate of multiplication* (*biotic potential*).

A knowledge of the number of times an insect will multiply in one generation under known conditions will indicate whether those conditions are favourable or not for the development of an infestation, but it tells nothing of the speed with which the infestation could develop. This is dependent upon the time the insect takes to develop from the egg to the egg-laying adult (fig. 2 A). Now, this factor has been incorporated with the data on the rate of multiplication in one generation by multiplying the values in Tables I and II by 100 ÷ days required for development from egg to adult. This gives the rate of multiplication in 100 days (the biotic potential). Fig. 6 has been derived in this way. It shows the rate of multiplication of the two species over their complete temperature range in wheat of 14%, 12%, 11% and 10% moisture content.

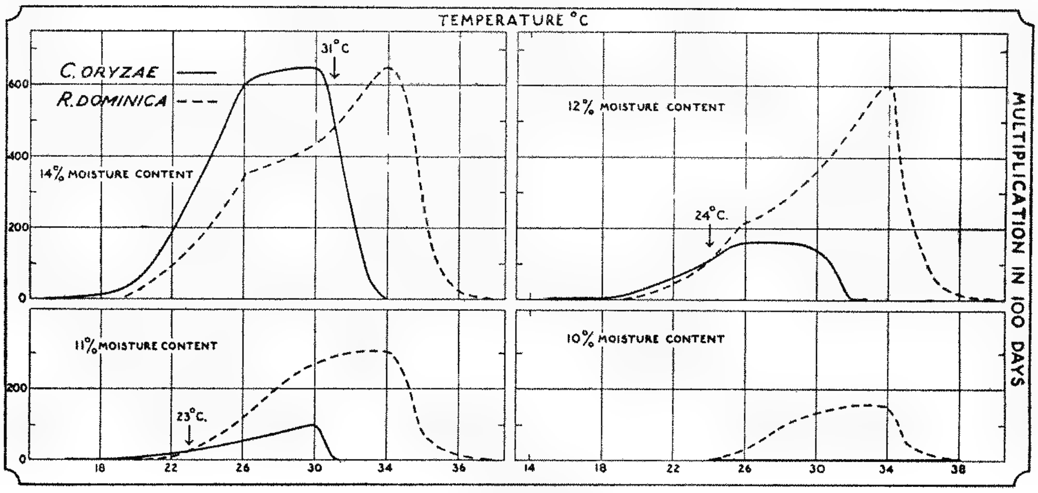
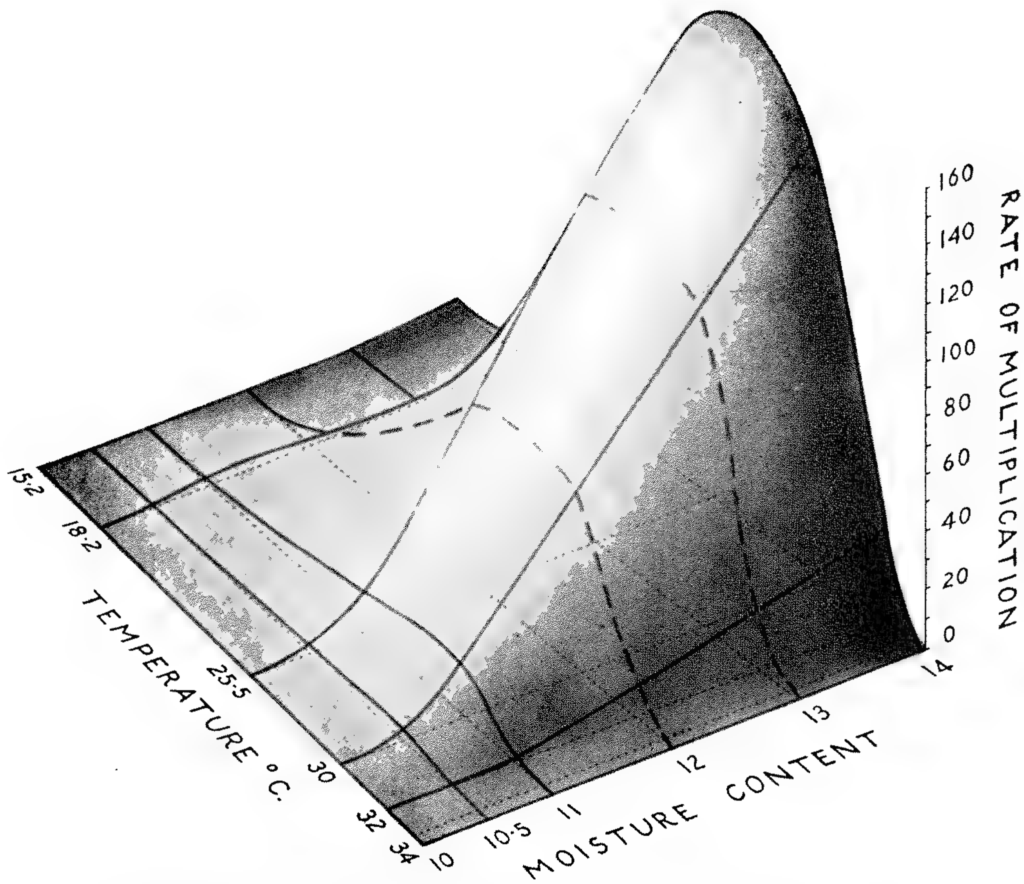


Fig. 6

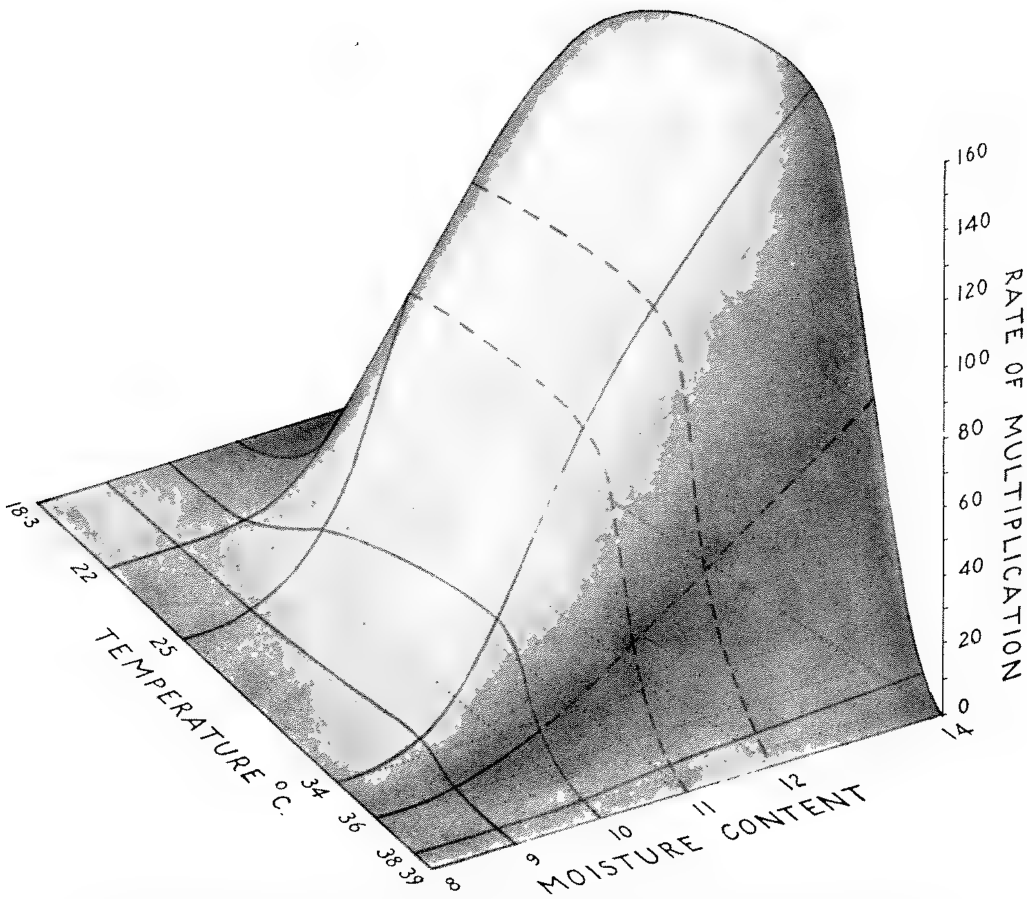
Showing the rate of multiplication in 100 days (biotic potential) of *Rhizopertha dominica* and *Calandra oryzae* in wheat of moisture contents of 14%, 12%, 11% and 10%. The vertical arrows show the temperatures above which *R. dominica* multiplies more rapidly than *C. oryzae*.

Fig. 6 shows that *C. oryzae* multiplies more rapidly than *R. dominica* in wheat of 14% moisture content at all temperatures up to 31° C. At temperatures higher than 31° C. *R. dominica* multiplies more rapidly. In wheat of 11% moisture content *C. oryzae* could only multiply more rapidly than *R. dominica* at temperatures below 23° C. In wheat of 10% moisture content *C. oryzae* is unable to multiply at all, but *R. dominica* can multiply in wheat as dry as this at temperatures between 24° and 38° C.

The biotic potential of *R. dominica* shown in fig. 6 is based on figures for mortality of the immature stages developing in sound grain. Since the mortality is less in grain which has been damaged, the biotic potential will be greater under these conditions. In the early stages of an infestation of stored grain, the biotic potential would be less than when the infestation had become established. The range of temperature and moisture content of wheat within which the insects can survive is also greater when the grain is damaged. This means that in some conditions *R. dominica* behaves as a primary pest in the sense of being able to establish an infestation in sound grain, *e.g.*, at 34° C. in wheat of 9% moisture content. Under certain conditions, however, it behaves as a secondary pest, *e.g.*, at 36° C. in wheat of 9% moisture content the biotic potential is zero in sound grain, but it has a value of 3 in damaged grain.



Three-dimensional diagram showing the rate of multiplication in one generation of the small strain of *Calandra oryzae* (*c.f.* Table I). Broken lines connect points which have been interpolated.



Three-dimensional diagram showing the rate of multiplication in one generation of *Rhizopertha dominica* (*c.f.* Table II). Broken lines connect points which have been interpolated.

Summary

An account is given of the biotic constants for egg-laying, development and survival of the small strain of *C. oryzae* and *R. dominica*. This data is combined to show the potential rate of multiplication of the two species over the complete range of temperature and moisture within which any increase can occur.

All the stages of *R. dominica* were more resistant to dryness than those of *C. oryzae*, and they were able to develop at higher temperatures. Wheat of 10·5% moisture content was the driest in which *C. oryzae* was able to develop, whereas *R. dominica* survived in grain of 9% moisture content. The highest temperatures at which the two species were able to develop was 32·3° C. for *C. oryzae* and 38·2° C. for *R. dominica*. The egg stage of both species was the most resistant to the harmful effects of dryness and high temperature. The least resistant stage was the first larval instar.

The rate of oviposition of *R. dominica* was maintained at a high level at all moisture contents between 14% and 9%. With *C. oryzae*, on the other hand, the rate of oviposition fell greatly with any reduction of moisture content below 13%. The maintenance of a high rate of oviposition by *R. dominica* in dry wheat enables it to multiply rapidly despite the high mortality of the immature stages under these conditions.

The two species have about the same maximum potential rate of increase when each is provided with optimum conditions. But their optimum conditions occur in different parts of the temperature and moisture scales. In wheat of 14% moisture content, *C. oryzae* multiplies more rapidly than *R. dominica* at all temperatures up to 31° C. At temperatures higher than 31° C., *R. dominica* multiplies more rapidly. In wheat of 11%, however, *C. oryzae* could only multiply more rapidly at temperatures below 23° C.

Acknowledgments

Grateful acknowledgments are made to Professor J. Davidson and Mr. H. G. Andrewartha for their advice and helpful criticism, and to Miss H. M. Brookes who made the final drawings for the figures.

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SOUTHERN AUSTRALIAN GASTROPODA PART 1. STREPTONEURA

BY BERNARD C. COTTON (READ 14 JUNE 1945)

Summary

The following species have been picked from dredgings and material collected by the late Sir Joseph Verco, the author and others. Although sorting and identifying the minutae from shell sand is a slow process the results are well worth while. In this paper a number of new and definite localities are recorded and observations on the variability of species noted. This paper covers only preliminary notes relating to the subclass Streptoneura.

SOUTHERN AUSTRALIAN GASTROPODA
PART I. STREPTONEURA

By Bernard C. Cotton

[Read 14 June 1945]

Plates XII and XIII

The following species have been picked from dredgings and material collected by the late Sir Joseph Verco, the author and others. Although sorting and identifying the minutae from shell sand is a slow process the results are well worth while. In this paper a number of new and definite localities are recorded and observations on the variability of species noted. This paper covers only preliminary notes relating to the subclass Streptoneura.

Scissurona vincentiana sp. nov.

Pl. xii, fig. 5, 6

Shell ear-shaped, translucent, white, with pink apex; spiral threads on the upper part, sharp, distant keels on the lower portion, all crossed by faint accremental striae; spire elevated, adult whorls three, early whorls rounded, last oval, flattened above; mouth large, oval, oblique; slit deep, well above the periphery; columella concave, broad, with a moderate lobe over the narrow umbilicus. Height 1·2 mm., diameter 1·35 mm.

Loc.—South Australia: Gulf St. Vincent; Glenelg, shell sand (type loc.); Guichen Bay; Minlacowie. Victoria: Port Fairy. Western Australia: Albany.

Remarks—This species differs from *remota* Iredale 1924, New South Wales, in its greater size and higher spire. A synonym is *Scissurella obliqua* Pritchard and Gatliff 1903, not Watson 1886. *S. rosea* Hedley 1904, from New Zealand, is distinct. The present species is figured by the writer, as *S. remota,* in the S. Aust. Nat., 1933, **15**, pl. i, fig. 9. Holotype, Reg. No. D. 14109, S. Aust. Museum.

Schizotrochus gunteri Cotton and Godfrey

Schizotrochus gunteri Cotton and Godfrey 1933, S. Aust. Nat., **15**, 23,, pl. i, fig. **11**.

Loc.—South Australia: Beachport, 150 fms. (type loc.), 200 fms.; Cape Jaffa, 100, 130 and 300 fms.; Cape Wiles, 100 fms.

Remarks—Less strongly sculptured than the *australis* Hedley 1903 from New South Wales but not South Australia, although attaining to almost the same size.

Family FISSURELLIDAE

Hemitoma subemarginata (Blainville)

Emarginula subemarginata Blainville 1819, Dict. Sci. Nat., **14**, 382.

Loc.—South Australia: MacDonnell Bay (type loc.); Guichen Bay; Streaky Bay; Kangaroo Island; Rapid Head, 9 to 12 fms.; Eastern Cove, 9 fms.; Hardwicke Bay, 9 fms.; Investigator Straits, 8, 15 and 17 fms.; Edithburgh, 5 fms.; Point Marsden, 13 and 17 fms.; Backstairs Passage, 8, 13, 16, 17, 18, 19, 20 and 22 fms.; Yankalilla Bay, 10, 12 and 20 fms.; Thistle Island, 12 fms.; Gulf St. Vincent, 9 fms.; Porpoise Head, 17 fms.; American River, 8 fms.; Black Point, 14 fms.; Western Cove, 10 fms.; Wallaroo, 15 fms.; St. Francis Island,

15, 20 and 35 fms. Western Australia: Hopetoun; Ellenbrook; Bunbury, 22 fms.; eight miles west of Eucla, 81 fms.; Esperance; Rottnest; Albany; King George Sound.

Remarks—Alive from 5 to 20 fms. and common on rocks just below low tide. The young has a distinct slit fasciole pitted by successive slit margins and slightly curved to the right of the middle line, giving an asymmetrical appearance. The radula has an average-sized central tooth, fairly wide, not serrated laterals, overlapping; a distinct line running across the central and laterals about midway in their length; major lateral bicuspid; marginals numerous and serrated.

Foralepas bakeiei (Sowerby)

Macroschisma bakeiei Sowerby 1886, Thes. Conch., **3**, 206, pl. ccxliv, fig. 221.

Loc.—Western Australia: Albany (type loc. here designated); Hopetoun; Rottnest; Yallingup; Ellenbrook; Bunbury; Geraldton.

Remarks—The shell is smaller, thicker, wider and decidedly more coarsely sculptured than *Foralepas tasmaniae* from the eastern end of the Flindersian Region. The animal is very large in proportion to the shell and gleaming white. The shell is situated well to the front covering the vital organs, while the posterior portion of the animal is uncovered. The species is usually attached to the undersurface of smooth rocks deeply buried in clean sand. This situation serves as a protection for such a vulnerable animal.

Dolichoschisma producta (Adams)

Macroschisma producta Adams 1850, Proc. Zool. Soc., 202.

Loc.—South Australia: Port Lincoln (type loc.); Normanville; American River; Beards Bay; Black Point; Hardwicke Bay; Edithburgh; Pondolowie Bay; Yankalilla Bay, 12 to 15 fms.; Backstairs Passage, 20 fms.; Investigator Straits, 15 fms.; St. Francis Island, 15 to 20 fms.

Dolichoschisma munita (Iredale)

Dolichoschisma producta munita Iredale 1940, Aust. Zool., **9**, (4), 431.

Loc.—Western Australia: Geraldton (type loc.); King George Sound; Albany; Rottnest; Hopetoun; Bunbury, alive in shallow water, dead on the beach.

Remarks—Records of "*Dolichoschisma producta* Adams" from Western Australia are really this species, which is smaller and has well-developed foramen and sinus features and finer scupture.

Family TROCHIDAE

Microclanculus gatliffi (Tomlin.)

Clanculus gatliffi Tomlin. 1924, Proc. Mal. Soc., **16**, 24, text fig.

Loc.—Western Australia: Fremantle (type loc.); Bunbury.

Remarks—An examination of cotypes from Gatliff suggests that this is at most a subspecies of *euchelioides* Tate 1893, being the Western Australian form.

Minolops corallina (Cotton and Godfrey)

Gibbula corallina Cotton and Godfrey 1935, S. Aust. Nat., **16**, 35, text fig.

Loc.—South Australia: Gulf St. Vincent (type loc). Western Australia: Rottnest; Yallingup; King George Sound; Ellenbrook; Bunbury.

Remarks—The species must be rare in South Australia, as only the type specimens taken by Dr. Basedow are known from there.

Family STOMATIIDAE

Stomatia australis Adams

Stomatia australis Adams 1850, Proc. Zool. Soc., 34.

Loc.—Northern Australia (type loc.). Western Australia: North West; Geraldton; Rottnest Island.

Remarks—Probably closely related to the genotype *phymotis* Helbing 1779. It has not yet been taken in western South Australia.

Gena auricula (Lamarck)

Stomatella auricula Lamarck 1816, Tabl. Encyc. Meth., Liste, **10,** pl ccccl, fig. a–b.

Loc.—Western Australia: King George Sound (type loc.). South Australia: general on reefs amongst weeds below low tide; abundant dredged alive on seaweeds, stones and ascidians in 5 fms. and down to 9 fms. Victoria. Tasmania.

Remarks—Moves quickly along the surface of rocks. Coarser and larger than the Peronian *Gena impertusa* Burrows = *strigosa* Adams and the Queensland *nigra* Quoy and Gaimard.

Family STOMATELLIDAE

Vaceuchelus ampullus (Tate)

Euchelus ampullus Tate 1893, Trans. Roy. Soc. S. Aust., 197, pl. i, fig. 5.

Loc.—Western Australia: Cambridge Gulf; North Western Australia (type loc.?); Rottnest; Yallingup; Albany; Ellenbrook; Geraldton; King George Sound; beach and alive down to 22 fms. South Australia: West Coast; Beachport; St. Francis Island, 35 fms. Tasmania: North Coast. Queensland: Caloundra.

Remarks—Holotype, Reg. No. D. 14182. The holotype and cotypes have the locality "W.A." It is common in southern Western Australia; much rarer in South Australia.

Vaceuchelus profundior (May)

Euchelus profundior May 1915, Proc. Roy. Soc. Tas., 98, pl. vii, fig. 39.

Loc.—South Australia: Beachport, 150 and 200 fms. Western Australia: 80 miles west of Eucla, 81 fms.; 40 miles west of Eucla, 72 fms.

Remarks—This is probably a deep water subspecies of *ampullus* Tate 1893, and some specimens intergrade with examples of Tate's species from 20 to 50 fms.

Herpetopoma pumilio (Tate)

Euchelus pumilio Tate 1893, Trans. Roy. Soc. S. Aust., **17,** 196, pl. i, fig. 3.

Loc.—South Australia: Fowler Bay (type loc.); Streaky Bay; Minlacowie; Robe. Western Australia: Rottnest; Bunbury; Yallingup; King George Sound.

Remarks—More depressed than *fenestratus,* five lirae on the body whorl, stouter and more distant and more vertical axial riblets, feebler nodosities at the intersections. Holotype, Reg. No. D. 13393, S. Aust. Museum.

Herpetopoma scabriusculus (Adams and Angas)

Euchelus scabriusculus Adams and Angas 1867, Proc. Zool. Soc., 215.

Loc.—New South Wales: Port Jackson (type loc.). Victoria: Port Fairy. South Australia: Beachport, 40, 100, 110 and 200 fms.; Backstairs Passage, 20 fms.; Cape Jaffa, 90 and 130 fms.; St. Francis Island, 15 to 20 fms.; Gulf St. Vincent, 10 fms.; Cape Borda, 55 fms.; Ardrossan, 6 to 8 fms.; alive on reefs

just below low tide and down to 10 fms.; also dead on beach Wallaroo, Venus Bay, Edithburgh, Murat Bay, Gulf St. Vincent and Spencer Gulf. Tasmania: Rocky Shores, down to 10 fms.

Remarks—Distinguished from *vixumbilicatus* by the narrow reddish to brown shell and closer, finer sculpture with obsoletely latticed narrower interstices. A synonym is *Euchelus tasmanicus* Tenison Woods 1876, from Tasmania.

Herpetopoma vixumbilicatus (Tate)

Euchelus vixumbilicatus Tate 1893, Trans. Roy. Soc. S. Aust., **17**, 196, pl. i, fig. 4.

Loc.—South Australia: West Coast of South Australia (type loc.); Streaky Bay; Venus Bay; Point Sinclair; St. Francis Island; Guichen Bay; Robe; Cape Borda, 55 fms.; Gulf St. Vincent; Marino, 5 fms. Western Australia; Ellenbrook; Hopetoun; Yallingup; Rottnest; King George Sound, beach and 28 fms.; Bunbury, 15 fms.; 90 miles west of Eucla 100 fms., 20 miles west 300 fms.; Shark Bay; alive in shallow water and dead from 60 to 100 fms.

Remarks—The white colour, pink spotting, broader shell, well developed latticed scupture distinguish this shell from *scabriusculus* Adams and Angas from New South Wales and extending into South Australia. Holotype, Reg. No. D. 13394, S. Aust. Museum.

Herpetopoma fenestrata (Tate)

Euchelus fenestratus Tate 1893, Trans. Roy. Soc. S. Aust., **17**, 195, pl. i, fig. 2.

Loc.—Western Australia (type loc): Rottnest; King George Sound; Bunbury, 15 fms. South Australia: Gulf St. Vincent; Normanville; West Coast; St. Francis Island, dredged; Beachport, 40 and 150 fms.; Cape Borda, 55 fms.; Neptunes, 45 fms.; St. Francis Island, 15 to 20 fms., alive on reefs in shallow water and down to 20 fms., dead from 55 to 150 fms.

Remarks—Distinguished by the clathrate sculpture, elevated spire, biangulated whorls, imperforate base. Holotype, Reg. No. D.13396.

Herpetopoma annectans (Tate)

Euchelus annectans Tate 1893, Trans. Roy. Soc. S. Aust., **17**, 196.

Loc.—Western Australia (type loc.): Albany; Ellenbrook. South Australia: Reevesby Island.

Remarks—Distinguished from *vixumbilicatus,* though generally similar in shape, in being imperforate, and consequently having no umbilical beaded cingulus; from *pumilio* it differs in having five instead of two spiral lirae on the penultimate whorl. The species is close in general appearance to *vixumbilicatus.* Holotype, Reg. No. D. 13395.

Herpetopoma aspersus (Philippi)

Trochus aspersus Philippi 1844, Zeitschr. für Malakoz., 103.

Loc.—Western Australia (type loc. *baccatus* Menke 1843, and possibly of *aspersus* Philippi): Bunbury; Yallingup, Rottnest; Albany; Geraldton. South Australia: Gulf St. Vincent; St. Francis Island; Spencer Gulf; Cape Borda, 55 fms.; Tunk Head, 16 fms.; Beachport, 40 and 150 fms.; Guichen Bay; Port MacDonnell; Wallaroo, beach and 15 fms.; Port Elliston.

Remarks—Monodonta baccatus Menke 1843, not Defrance 1824, is a synonym. Philippi 1846 gives as original reference "*Trochus aspersus* Koch 1846, Zeitsch. für Malakoz., 103." A variant represented by one or two specimens from South Australia has the granules radially elongate giving the shell quite a different appearance under 10 diams. magnification.

Family LIOTIIDAE

MUNDITIA TASMANICA (Tenison Woods)

Liotia tasmanica Tenison Woods 1875, Proc. Roy Soc. Tas., 153.

Loc.—Tasmania: Long Bay (type loc.). South Australia: Yankalilla Bay, 9. to 20 fms.; Rapid Head, 10 to 12 fms.; Gulf St. Vincent, 7 fms.; Spencer Gulf, 13 fms.; Backstairs Passage, 22 fms.; Investigator Straits, 15 fms.; Port Lincoln, 9 fms.; Newland Head, 20 fms.; Point Marsden, 15 fms.; Beachport, 40 to 150 fms.; Wallaroo, 15 fms.; Ardrossan, 6 fms., alive down to 40 fms., many at 22 fms. New South Wales. Victoria.

Remarks—Synonyms are *incerta* Tenison Woods, immature, and *tasmanica* var. *scalaris* Hedley 1903, New South Wales. *Delphinula syderea* Reeve 1843 from the Philippines was a name incorrectly used for the South Australian shell. The distinguishing feature of this species is the nodular projecting tubercles on the periphery whorls. There is a certain amount of variation in South Australian specimens. Adults may vary in maximum diameter from 3·5 mm. to 8 mm. The axials may number from 12 to 16 and sometimes are distinct from the suture outwards, or scarcely visible on the dorsum but standing out at the angle as large, sharp, triangular tubercles. Similarly, the spirals which may be prominent and stout on the dorsum form a marked tuberculation with axials, or in others may be just visible. In some there may be a peripheral carina almost as large as the upper one which forms the dorsal angle, with a fairly well marked one in between, while in others all but the dorsal one may be obsolete. The carina forming the basal angulation is generally well marked, but even this may be obsolete. The axials in some become much reduced towards the aperture. The degree of descent of the last whorl towards the aperture varies, as does also the elevation of the spire, which in most is quite flat, but rarely slightly raised. The axial lirae vary much in their distinctness. The radula of a South Australian specimen has the formula $\infty+5+1+5+\infty$, a central denticle, five laterals and an indefinite number of about 75 marginals. It is very like the figure of "*Leptothyra carpenteri*" given by Pilsbry, in Tryon's Manual Conch., **10**, pl. 60, fig. 73. The median tooth is provided with a narrow elevated part above, and this is hooked over to form a median, slightly serrated cusp; below this there is a ledge, which is not a projecting thickening but is due to the recession of the parts below it. The lateral margins are expanded into projecting wings, and these rest upon corresponding projections from the adjacent laterals. Extending above the cusp, and lying behind it is an accessory plate. The laterals are long and very oddly shaped. There is an obliquely-placed serrated cusp at the top; then a plate at the upper part projecting outwards on which lies the inner upper part of the next outer marginal. Below this is another thicker and somewhat twisted plate which, like the expanded wings of the central tooth, rests in front of a plate projecting from the inside of the next lateral. The lower end is somewhat pointed. The outermost lateral is slightly different from the others in that it wants the two expansions from its outer side. The central tooth stands a little lower than its adjacent laterals, the innermost three of these rise successively higher, the fourth is lower and the fifth lower still. The first 10 or 12 marginals are hooked, the hooks being smooth, but there is a notch in the stem immediately beneath the hook. These are all joined by another and finer piece to a horizontal rod, about as long as the stem of the marginal. The next marginals are serrated on both edges of the hook, and notched underneath, and on each successive marginal has the hook shorter, until it is finally reduced to a mere bending forward or thickening of the top of the stem with serrated edges, and the knobs gradually lessen in size; finally they appear to be reduced to acicular uncini with thin, curved ends, two of which needles may be articulated to a divided lower limb.

Munditia hedleyi (Pritchard and Gatliff)

Liotia hedleyi Pritchard and Gatliff 1899, Proc. Roy. Soc. Vict., **12**, 105, pl. viii, fig. 8, 9, 10.

Loc.—Victoria: Flinders Beach; Western Port (type loc.). South Australia: Gulf St. Vincent, 17 fms.; Backstairs Passage, 17 fms.; Beachport, 100, 110, and 150 fms.; Cape Jaffa, 130 fms., alive down to 17 fms.

Remarks—Distinguished by the strong, spaced axials crossing and serrating the spirals and extending from suture to umbilicus. Somewhat resembling the tropical Philippine *Liotina discoidea* Reeve which occurs in Northern Australia but which does not have the axials continued on to the base.

Munditia australis (Kiener)

Delphinula australis Kiener 1839, Coq. Viv., **10**, 8, pl. iv, fig. 7.

Loc.—South Australia: Islands of St. Peter and St. Francis (type loc.); Yankalilla Bay, 15 fms.; Rapid Head, 10 and 12 fms.; Investigator Straits, 15 fms.; Gulf St. Vincent, 10 and 20 fms.; Backstairs Passage, 17, 19, 20 and 22 fms.; Newland Head, 20 and 24 fms.; Porpoise Head, 17 fms.; Middleton, 10 fms.; Beachport, 40 and 110 fms.; Tunk Head, 16 fms., alive down to 40 fms. Tasmania: North Coast. Victoria: Western Port; Port Fairy. Western Australia: Bunbury; Fremantle; King George Sound; Esperance; Hopetoun, 25 fms.

Remarks—South Australian specimens vary greatly in adult size when the aperture has formed a varix. They range from 5 mm. in diameter in a micromorph to 14 mm. in macromorph. The "beaded riblet winding into the umbilicus" is composed of four or five axial lirae which bend towards one another and unite to form a small furrowed flame-like pyramid ending in a fine point. The varix of the mouth is in two parts, the second portion being of less diameter than the first; both have rounded tubercles on their margin formed by expansions of the spiral ribs. These tubercles touch one another between the two parts. Specimens examined in which the animal has been devoured have the shell bored in and about the base, the hole being in or near the umbilicus, only one has a dorsal hole. The operculum has a granular external surface and is very close fitting, so as to remain *in situ* when the mollusc has been devoured.

Munditia densilineata (Tate)

Liotia densilineata Tate 1899, Trans. Roy. Soc. S. Aust., **23**, **228**.

Loc.—Tasmania: D'Entrecasteaux Channel (type loc.); Pilot Station, 10 fms. South Australia: Beachport, 40, 110, 150 and 200 fms.; Cape Borda, 55 fms., alive down to 10 fms.

Remarks—It is suggested by Tate that the holotype description may be based on an immature specimen, and indeed the shell does recall an immature *Munditia australis,* though probably quite distinct from that species. In *Munditia subquadrata* the spiral sculpture consists also of fine threadlets, but its revolving ridges are few and bold, imparting a quadrate outline to the last whorl. Holotype, Reg. No. D.13413.

Munditia mayana (Tate)

Liotia mayana Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 227, pl. vi, fig. 5, a, b, c.

Loc.—Tasmania (type loc.), dredged 50 to 100 fms. Victoria: Western Port. South Australia: Spencer Gulf, 20 fms.; Backstairs Passage, 16, 17, 18, 19, 20 and 22 fms.; Investigator Straits, 13 and 15 fms.; Port Lincoln, 9 fms.; Point Marsden, 15 fms.; Porpoise Head, 17 fms.; Beachport, 110 and

150 fms.; Newland Head, 20 and 24 fms.; Tunk Head, 16 fms.; Wallaroo, 15 fms.; Cape Jaffa, 130 fms., alive down to 40 fms.

Remarks—Resembles in size and general appearance *Munditia subquadrata*, but the suture is not excavated, the aperture not so explanulately thickened and the columella margin is detached from the umbilical rim. Holotype, Reg. No. D.13413, S.A. Museum.

Munditia subquadrata (Tenison Woods)

Liotia subquadrata Tenison Woods 1878, Proc. Linn. Soc. N.S.W., **2**, 236.

Loc.—Tasmania: Long Bay (type loc.); Blackman's Bay, all round the coast in shallow water. Victoria: Western Port. South Australia: Gulf St. Vincent, 5 fms.; Porpoise Head, 17 fms.; Middleton, 10 fms.; Backstairs Passage, 22 fms.; Beachport, 40, 110 and 150 fms.; Cape Jaffa, 130 fms., alive down to 10 fms. Western Australia: Hopetoun, 25 fms.

Remarks—The holotype is a juvenile of 3 mm. diameter. South Australian specimens range between 5 mm. to 6·5 mm. in diameter; Tasmanian attain to 9 mm. South Australian specimens may have the axials continued to the apertural varix or the last third of the whorl may be free from them.

Charisma arenacea (Pritchard and Gatliff)

Leptothyra arenacea Pritchard and Gatliff 1901, Proc. Roy. Soc. Vict., **14, 181**, pl. ix, fig. 3.

Loc.—Victoria: Rhyll; Phillip Island; Western Port, 5 to 6 fms. (type loc.). Tasmania: Thouin Bay, 40 fms. South Australia: Backstairs Passage, 17 fms.

Remarks—The species is distinguished by the well-defined spiral ridges.

Charisma josephi (Tenison Woods)

Cyclostrema josephi 1877, Proc. Roy. Soc. Tas., 147.

Loc.—Tasmania: Blackman's Bay (type loc.), 10 to 100 fms., common in deep water. Victoria: Western Port. South Australia: Backstairs Passage, 20 and 22 fms.; Cape Borda, 62 fms., living at around 20 fms. Western Australia: Ellenbrook; Yallingup.

Remarks—A stout, somewhat globular shell, with the first two or three whorls smooth, the rest spirally engraved, umbilicus well marked, with a rounded axially finely striated pad; mouth round, entire, bevelled inside, flat margined. The operculum is multispiral and apparently thinly calcareous exteriorly.

Charisma carinata (Verco)

Leptothyra carinata Verco 1907, Trans. Roy. Soc. S. Aust., **31**, pl. xxix, fig. 8.

Loc.—South Australia: Backstairs Passage, 20 fms. (type loc.); Newland Head, 20 fms., dead; St. Francis Island, 6 fms., alive.

Remarks—Distinguished from *arenacea* by the more marked carinae, more widely canaliculated suture and wider umbilicus of the present species. Holotype, Reg. No. D.14199.

Argalista fugitiva Hedley 1911

Leptothyra fugitiva Hedley 1911, Zool. Res. Endeavour, **1**, 104, pl. xviii, fig. 18, 19, 20.

Loc.—South Australia: Cape Wiles, 100 fms. (type loc.); Beachport, 110 fms.

Remarks—Smaller, flatter, more finely grooved than any other Australian species, such as *rotatum* Hedley 1899, from Tutaga Islet, Funafuti, 200 fms., *roseopunctata* Angas 1880, from South Australia, and *rosea* Tenison Woods 1876, from Tasmania.

AGALISTA ROSEOPUNCTATA (Angas)

Collonia roseopunctata Angas 1880, Proc. Zool. Soc., 417, pl. xl, fig. 8.

Loc.—South Australia: Holdfast Bay, in shell sand (type loc.); MacDonnell Bay; Cape Borda, 62 fms.

Remarks—The dotted rose colouring and solid shell distinguish this species.

STARKEYNA CANCELLATA (Tate)

Ethalia (?) *cancellata* Tate 1878, Trans. Roy. Soc. S. Aust., **2**, 139, pl. v, fig. 11a, 11c.

Loc.—South Australia: Holdfast Bay; Gulf St. Vincent (type loc.); Streaky Bay; Fowlers Bay; Great Australian Bight; St. Francis Island, 6 and 35 fms.; Beachport, 40 fms. Western Australia: Rottnest.

Remarks—Holotype, Reg. No. D.14110, S. Aust. Museum.

CALLOMPHALA LUCIDA Adams and Angas 1864

Callomphala lucida Adams and Angas 1864, Proc. Zool. Soc., 35.

Loc.—New South Wales: Coogee Bay, in shell sand (type loc.). South Australia: Robe; St. Francis Island, shell sand; Beachport, 40 and 110 fms.; Cape Borda, 55 and 62 fms., alive in shallow waters down to 5 fms., dead from 10 to 110 fms. Victoria: Western Port. Tasmania: ?.

Remarks—Rare in South Australia, only one or two specimens from each of the above localities.

CIRSONELLA WELDII (Tenison Woods)

Cyclostrema weldii Tenison Woods 1876, Proc. Roy. Soc. Tas., 147.

Loc.—Tasmania: Long Bay, 20 fms. (type loc.), shallow water to 100 fms., common; North Coast (type loc. *susonis*). New South Wales: Botany Bay (type loc. *australis*). South Australia: MacDonnell Bay; Robe; Sceales Bay; Arno Bay, dredged; Gulf St. Vincent, 10 fms.; Cape Borda, 62 and 90 fms.; Cape Jaffa, 49 and 300 fms.; Beachport, 40, 110 and 150 fms.; Investigator Straits, 20 fms., alive down to 90 fms. and shells in good condition, probably living specimens down to 150 fms., dead shells in deeper water.

Remarks—Not common in South Australia. Synonyms are *australis* Angas 1877 and *susonis* Tenison Woods 1877.

CIRSONELLA TRANSLUCIDA May

Cirsonella translucida May 1915, Trans. Roy. Soc. Tas., 97, pl. vii, fig. 39.

Loc.—Tasmania: Thouin Bay, 40 fms. (type loc.). South Australia: Beachport, 40 fms.; Cape Borda, 55 fms.; Venus Bay. Western Australia: King George Sound.

Remarks—Varies much in size, average smaller in South Australia.

LISSOTESTA MICRA (Tenison Woods)

Cyclostrema micra Tenison Woods 1876, Proc. Roy. Soc. Tas., 147.

Loc.—Tasmania: Long Bay (type loc.), 10 to 100 fms. Victoria: Western Port. South Australia: Backstairs Passage, 20 fms.; Cape Borda, 55 fms.; Beachport, 40 fms.; Cape Jaffa, 49 fms.

Remarks—Rare in South Australia.

LISSOTESTA CONTABULATA (Tate)

Cyclostrema contabulata Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 222, pl. vii, fig. 6.

Loc.—South Australia: Streaky Bay (type loc.); Fowlers Bay; Smoky Bay; Murat Bay; Gulf St. Vincent; Robe, in shell sand in great numbers; Beachport, 40 fms., dredged alive in numbers in weeds, St. Francis Island, 6 and 35 fms. Tasmania: Frederick Henry Bay; rare. Western Australia: King George Sound, beach and down to 24 fms.

Remarks—Holotype, Reg. No. D.13405, S. Aust. Museum.

LISSOTESTA PORCELLANA (Tate and May)

Cyclostrema porcellana Tate and May 1900, Trans. Roy. Soc. S. Aust., **24**, 101.

Loc.—Tasmania: Frederick Henry Bay (type loc.). South Australia: Cape Borda, 55 fms., one specimen only. Victoria: Port Fairy.

Remarks—More conic than *contabulata* and *micra*. A synonym is *Rissoa translucida* May 1912.

Eudaronia gen. nov.

Genotype: *Cyclostrema* (*Daronia*) *jaffaensis* Verco 1909—South Australia.

Shell small, planorbid of two whorls, with a carinating cord above and below, suture impressed, aperture reniform, peristome simple, thin, not continuous, spread as a thin glaze over the preceding whorl; umbilicus very wide and perspective; spire sunken.

Distribution—Southern Australia and Tasmania.

Remarks—The genus differs from *Daronia*, genotype *Daronia spirula* Adams 1861 from the Philippines, in the discontinuous peristome, which must be regarded as an important generic feature.

EUDARONIA JAFFAENSIS (Verco)

Cyclostrema (*Daronia*) *jaffaensis* Verco 1909, Trans. Roy. Soc. S. Aust., **23**, 270, pl. xx, fig. 6, 7.

Loc.—Cape Jaffa, 90 fms. (type loc.) 49 fms. Tasmania: Schouten Island, 80 fms.; Cape Raoul, 50 fms.

Remarks—Holotype, Reg. No. D13411, S. Aust. Museum.

LODDERIA LODDERAE (Petterd)

Liotia lodderae Petterd 1884, Journ. Conch., Lond., 135.

Loc.—Tasmania: Leven Heads (type loc.); North Coast, in shallow water. South Australia: Fowler Bay; American River; Kangaroo Island; Denial Bay; Streaky Bay; St. Francis Island, alive in shallow water just below low tide. Victoria: Western Port. New South Wales: Middle Harbour.

LODDERENA MINIMA (Tenison Woods)

Liotia minima Tenison Woods 1878, Trans. Roy. Soc. Vict., **14**, 58.

Loc.—Victoria: Western Port (type loc.). South Australia: Robe, in shell sand. New South Wales: Port Jackson.

CROSSEOLA CONCINNA (Angas)

Crossea concinna Angas 1867, Proc. Zool. Soc., 911, pl. xliv, fig. 14.

Loc.—New South Wales: Port Jackson (type loc.). Victoria: Western Port. Tasmania: North Coast. South Australia: rare, Gulf St. Vincent, 17 fms.; Newland Head, 20 fms.; Yankalilla and Robe, shell sand.

Remarks—Distinguished by the fine sculpture.

CROSSEOLA CARINATA (Hedley)

Crossea carinata Hedley 1903, Mem. Aust. Mus., **4**, 345, fig. 71.

Loc.—New South Wales: Port Kembla, 63-75 fms. (type loc.), 16 miles east of Wollongong, 100 fms. Tasmania: 40 to 100 fms., common. South Australia: Beachport, 110 fms.

Remarks—Distinguished by the globular shell, bluntly keeled at the periphery.

CROSSEOLA CANCELLATA (Tenison Woods)

Crossea cancellata Tenison Woods 1878, Proc. Roy. Soc. Tas., 122.

Loc.—Tasmania: Blackman's Bay (type loc.); Channel, 10 fms. South Australia: Gulf St. Vincent, 5 fms.; Newland Head, 20 fms.; Beachport, 40 and 150 fms.; Cape Borda, 55 fms., living down to 150 fms.

Remarks—Minute, cancellate.

CROSSEOLA CONSOBRINA (May)

Crossea consobrina May 1915, Proc. Roy. Soc. Tas., 97, pl. xxiii, fig. 1.

Loc.—Tasmania: Thouin Bay, 40 fms. South Australia, Beachport, 40 fms.

Remarks—Distinguished from *cancellata* by the square cut, non-channelled front of the columella, smaller umbilicus and less strongly cancellate sculpture.

DOLICROSSEA LABIATA (Tenison Woods)

Crossea labiata Tenison Woods 1875, Proc. Roy Soc. Tas., 151.

Loc.—Tasmania: Long Bay, 10 fms. (type loc.), 10 to 40 fms. South Australia: Beachport, 40 and 150 fms.; Cape Jaffa, 130 fms.; Investigator Straits, 20 fms.; Ardrossan, 14 fms.; Backstairs Passage, 18 fms.; Gulf St. Vincent, 5 and 9 fms.; Sceales Bay; Venus Bay; Holdfast and Aldinga Bays; Grange and Outer Harbour, shell sand.

Remarks—Distinguished by the narrow canaliculation of inner lip and the thickened and reflected outer lip. Related fossils are *Dolicrossea labiata sublabiata* Tate and *lauta* Tate.

BROOKULA ANGELI (Tenison Woods)

Rissoa angeli Tenison Woods 1876, Proc. Roy Soc. Tas., 153.

Loc.—Tasmania: Long Bay (type loc.); Blackman's Bay. South Australia: shell sand, Robe; and dredged Cape Borda, 62 fms.

Remarks—Distinguished by the ill-defined axial ribs, about as wide as the interspaces, becoming obsolete at the periphery and base, and numbering about 15 on the body whorl. Variable in shape. Variants are:

(*a*) The typical form has few stout axial ribs, about ten, ceasing at the periphery.

(*b*) The axial ribs may be almost obsolete but axial incision may be present on the earlier whorls, and also suggestion of ribbing on the body whorl, making the spirals faintly polygonal.

BROOKULA CREBRESCULPTA (Tate)

Cyclostrema crebresculpta Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 219, pl. vii, fig. 5.

Loc.—Tasmania: (type loc.), Channel, 10 fms. South Australia: Backstairs Passage, 10 fms.; Robe, shell sand.

Remarks—Besides the sculpture of crowded axial threads and interstitial spiral striae, there is also a microscopic sculpture of incremental striae.

BROOKULA NEPEANENSIS (Gatliff)

Scala nepeanensis Gatliff 1906, Proc. Roy. Soc. Vict., **1**, pl. i, fig. 5.

Loc.—Victoria: in shell sand, Ocean Beach; Point Nepean (type loc.). Tasmania: Storm Bay; Thouin Bay, 40 fms. South Australia: Cape Borda, 62 fms.; Backstairs Passage, 10 fms.

Remarks—Distinguished from *angeli* by the more definite axial ribs.

BROOKULA JOHNSTONI (Beddome)

Cyclostrema johnstoni Beddome 1882, Proc. Roy. Soc. Tas., 168.

Loc.—Tasmania: off Old Station, Brown's River Road, 7 fms. (type loc.). South Australia: Robe, in shell sand.

ZALIPAIS INSCRIPTA (Tate)

Cyclostrema inscriptum Tate 1899, Trans. Roy. Soc. S. Aust., **13**, 216, pl. vii, fig. 3.

Loc.—South Australia: West Coast (type loc.); Glenelg, shell sand; Cape Jaffa, 49 fms.; Beachport, 40 fms.; Cape Borda, 62 fms.; dredged alive down to 49 fms., dead to 62 fms.

Remarks—Distinguished by the flattened spire.

ZALIPAIS BRUNIENSE (Beddome)

Cyclostrema bruniensis Beddome 1883, Proc. Roy. Soc. Tas., 168.

Loc.—Tasmania: Cloudy Bay; Lagoon; South Bruny Island (type loc.). South Australia: Port MacDonnell. Victoria: Portsea.

Remarks—A minute brown, flattened shell.

ELACHORBIS TATEI (Angas)

Cyclostrema tatei Angas 1878, Proc. Zool. Soc. Lond., 862, pl. liv, fig. 10.

Loc.—South Australia: Holdfast Bay, shell sand (type loc.); Largs Bay; Tourville Bay; St. Francis Island, beach; Point Sinclair, 15 to 20 fms.; Beachport, 40, 110 and 150 fms.; Cape Jaffa, 130 fms.; Cape Borda, 62 fms., alive in shallow water down to 5 fms. Western Australia: Bunbury; King George Sound.

Remarks—Two spiral keels, varying in strength, sometimes almost obsolete. Shell varying in thickness.

ELACHORBIS HARRIETTAE (Petterd)

Cyclostrema harriettae Petterd 1884, Journ. Conch., 215.

Loc.—Tasmania: North-west Coast (type loc.). South Australia: Robe; Holdfast Bay, shell sand; Newland Head, 28 fms.; Cape Borda, 62 fms., dead below 50 fms. Victoria: Port Fairy.

Remarks—A pure white species very closely allied to *tatei* but quite distinct, and has a more open umbilicus than *Elachorbis homalon* Verco 1907.

ELACHORBIS HOMALON (Verco)

Cyclostrema homalon Verco 1907, Trans. Roy. Soc. S. Aust., **31**, 305, pl. xxix, fig. 3, 4.

Loc.—South Australia: Cape Borda, 62 fms. (type loc.); Cape Jaffa, 130 fms.; Beachport, 110 fms.

Remarks—Holotype, Reg. No. D.13410. Related to *harriettae* but has a less open umbilicus, labrum not sinuous on the dorsum but having a continuous convex curve; the infra-umbilical spirals are much finer and more crowded.

ELACHORBIS CAPERATA (Tate)

Cyclostrema caperatum Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 216 pl. vii, fig. 1a-1b.

Loc.—Victoria: Lakes Entrance; Gippsland, in shell sand (type loc.). South Australia: Robe.

Remarks—Holotype, Reg. No. D.13407, S. Aust. Museum.

ELACHORBIS DELECTABILE (Tate)

Cyclostrema delectabile Tate 1899, Trans. Roy. Soc. S. Aust., **23**, 216.

Loc.—South Australia: Fowlers Bay, West Coast (type loc.); Backstairs Passage, 22 fms.

Remarks—Distinguished by the rather strong spiral sculpture meshed by axial threadlets. Holotype, Reg. No. D.13409, S. Aust. Museum.

Family TURBINIDAE

SUBNINELLA UNDULATUS (Solander)

Turbo undulatus Solander 1786, Portland Catalogue.

Loc.—Tasmania (type loc.). South Australia: Rapid Head, 9 and 11 fms., alive at low tide mark, common on reefs; both Gulfs; Ocean Beaches; Kangaroo Island; Pondolowie Bay; Point Sinclair; Venus Bay; St. Francis Island; Reevesby Island; Robe. Victoria. New South Wales. Western Australia: Albany; Yallingup; Esperance.

Remarks—South-Eastern specimens from Robe and vicinity are strongly ribbed above with supra, infrasutural and peripheral carinae conforming closely to the typical Tasmanian specimens. The species is plentiful and is locally called Common Warrener, being edible and suitable for bait. It is common on native kitchen middens at Cape Banks and vicinity generally.

NINELLA TORQUATUS (Gmelin)

Turbo torquatus Gmelin 1784, Syst. Nat., 3,597, No. 106.

Loc.—New South Wales: Port Jackson (type loc.). Queensland. Victoria. South Australia: both Gulfs; Corny Point; Kangaroo Island; Robe; Pondolowie Bay; Venus Bay; Point Sinclair; St. Francis Island, alive at low tide on reefs, dredged down to 5 fms. alive. Western Australia: Albany; Esperance; Yallingup; Bunbury; Rottnest; Ellenbrook; Cottesloe; Geraldton.

Remarks—Described originally as *Limax stamineus* Martyn 1784, not binomial. *Ninella torquatus lamellosus* Broderip is the Western Australian subspecies, type locality Garden Island, with higher whorls, markedly carinated at their centre with a stout cord, though there is variation and intergradation with *torquatus*.

EUNINELLA GRUNERI (Philippi)

Turbo gruneri Philippi 1846, Conch. Cab., 52, pl. xii, fig. 7, 8.

Loc.—South Australia: Gulf St. Vincent (type loc.); Yankalilla Bay, 15 fms.; Rapid Head, 9 fms.; Investigator Straits, 8, 10 and 15 fms.; Point Marsden, 13½ fms.; Porpoise Head, 12 fms.; Backstairs Passage, 22 fms.; Cape Borda, 62 fms.; Tunk Head, 16 fms. Beachport, 40 fms.; both Gulfs; Robe; Point Sinclair, alive on reefs in shallow water and down to 15 fms. Western Australia: Bunbury; Yallingup, beach and dredged; Bunbury, 22 fms.; King George Sound, 12 to 14 fms.; Hopetoun, 35 fms.; 80 miles west of Eucla, 80 fms. Tasmania.

Remarks—When quite young the shell has a distinct rimate umbilicus, as in a specimen dredged from 8 fms. The species occurs as a Pleistocene fossil in raised beaches, and also in the Pliocene.

Bellastraea squamifera (Koch)

Astralium squamiferum Koch 1852, Conch. Cab., 2, *Trochus*, 215, pl. xxxii, fig. 4 (Kuster).

Loc.—Western Australia (type loc.): Albany; Geographe Bay; Rottnest. South Australia: common in both Gulfs in shallow water, under weed-covered stones and down to 30 fms. alive; Yankalilla, 15 fms.; Rapid Head, 9 and 12 fms.; Eastern Cove, 9 and 5 fms.; Investigator Straits, 8 to 10 fms. many alive, 13, 15 and 17 fms.; Corny Point, 30 fms.; American River, Kangaroo Island, 8 fms.; Coffins Bay, 5 fms.; Spilsby and Reevesby Islands, 5, 10, 12 and 13 fms.; Beachport, 40 fms., dead; Point Sinclair; Arno Bay, Streaky Bay. Tasmania: North and West Coast. Victoria: Western Port; Port Fairy.

Remarks—Young shells, of about half an inch in diameter, are umbilicated, but older, not so. The animal has a small foot compared with the base of the shell; sole white, upper surface of foot black, spotted irregularly with white; muzzle black, but its open and exserted end quite white and kept nearly in the same plane as the sole and in front of it; tentacles are about one-third the length of the foot, white with three rather wide longitudinal black lines and with crowded sublenticular transverse black lines; eyes are on the outside of the tentacles close to their base on white peduncles separate from the tentacle proper; there are no lateral cilia; the shelly operculum is carried on the back of the foot, not quite centrally but a little to the right and rather far forward. Variants are as follows:

(*a*) The suprasutural margin markedly stellate, especially in the young, tending with age to become a corrugated lamella, but in some the stellate margin is retained even when quite large.

(*b*) Stellate at first, rapidly losing the sharp points and furnished with a very sharp lamelliform supramarginal edge.

(*c*) Higher, axially abundantly costate.

(*d*) Columellar callus abundant and forming a slightly projecting inner lip, which may extend somewhat beyond the region of the umbilicus.

Bellastraea tentoriformis (Jonas)

Astrea tentoriformis Jonas 1845, *Trochus*, Zeit. Malak., 2, 66.

Loc.—Western Australia (type loc.): Albany; Bunbury; Rottnest; Shark Bay; Geraldton. South Australia: Point Sinclair.

Remarks—This large, high shell is common in Western Australia, but its South Australian record is based on a specimen from the western end of that State, which is the limit of its eastern range. The species is distinguished from *squamifera* by the larger size, higher shell and pink to violet columella.

Micrastraea aurea (Jonas)

Trochus aureum Jonas 1844, Zeit. Malak., 2, 168.

Loc.—Western Australia (type loc.): Esperance; Albany; Rottnest; west of Eucla, 100 fms. South Australia: American River; both Gulfs, under weed-covered stones below low tide and on Razor Edge shells (*Pinna*); Glenelg; Normanville; Yorke Peninsula; Robe; Port MacDonnell, St. Francis Island; Point Sinclair; Streaky Bay; Beachport, 40 and 150 fms.; Eastern Cove, 5 fms., many alive; Troubridge; Port Lincoln, Investigator Straits, 15 fms. and 8 fms., alive down to 10 fms. Tasmania: common on rocky shores. Dredged alive in great abundance in seaweed off the sand-spit off Kingscote, Kangaroo Island, at about three to four miles from the shore in 9 fms., the larger ones covered with calcareous matter, the younger ones free; even more abundant in 5 fms.

MICRASTRAEA RUTIDOLOMA (Tate)

Turbo (*Astralium*) *rutidoloma* Tate 1893, Trans. Roy. Soc. S. Aust., **17**, **192**, pl. i, fig. 9.

Loc.—South Australia: at low tides, Moonta Bay (type loc.); Hardwicke Bay, 8 fms.; Reevesby Island; Arno Bay.

Remarks—Operculum shelly, thick, slightly angled at the columella side; and with a central weak depression much like *aurea.* The shell has an entirely different sculpture from *aurea.* Holotype, Reg. No. D.9965, S. Aust. Museum.

Family EUTROPIIDAE

PHASIANELLA AUSTRALIS (Gmelin)

Buccinum australis Gmelin 1788, Syst. Nat., 3490, No. 173.

Loc.—South Australia (type loc.): both Gulfs; Beachport; Robe; Rapid Head; Kangaroo Island; Port Lincoln; Arno Bay; Venus Bay; Point Sinclair; Corny Point, plentiful in patches of *Cymodocea* weed in shallow water at such places as Fort Largs; Gulf St. Vincent; largest specimens from Corny Point and west coast of Yorke Peninsula; juveniles under algae-covered stones; dredged alive down to 10 fms.; Gulf St. Vincent, 6 fms.; Semaphore, 5 fms.; Hardwicke Bay, 10 fms. Western Australia—King George Sound, 10, 12, 15, 24, 28 and 35 fms.; 90 miles west of Eucla, 100 fms.; Fremantle, 6, 10 and 15 fms.; Albany; Bunbury, 15 fms.; Geraldton. Tasmania: general, on weeds. Victoria: Western Port; Port Fairy.

Variants are:

(*a*) Colour of broad axial irregular dull red stripes—*"subsanguinea"* Pilsbry 1888.

(*b*) Surface tessellated by revolving series of squarish red blotches—*"venusta"* Reeve 1862.

(c) Narrow spaced spiral lines of close axial dashes and squares on an orange background.

Other synonyms which are named from varieties only are *tritonis* Chemnitz 1788, *bulimoides* Lamarck 1822 and *delicatula* Tenison Woods 1877.

MIMELENCHUS VENTRICOSA (Swainson)

Phasianella ventricosa Swainson 1822, Appendix to Cat. Coll. Shells Bligh, 12.

Loc.—Victoria (type loc.): general. South Australia: both Gulfs; Beachport; Kangaroo Island; Port Lincoln; Yorke Peninsula; West Coast; Point Sinclair; Rapid Head, 10 and 12 fms.; Investigator Straits, 8, 10, 15 and 20 fms.; Yankalilla Bay, 15 fms.; Encounter Bay, 15 fms.; Thorny Passage, 25 fms., alive down to 10 fms. Western Australia: Bunbury; Albany; Esperance; Ellenbrook; Yallingup; Fremantle; Rottnest. Tasmania: North and West Coast. New South Wales: Port Jackson.

Remarks—Synonyms are *perdix* Wood 1828, *sanguinea, zebra* and *reticulata* Reeve, *inflata* and *obtusa* Swainson 1822.

Variants are:

(*a*) Obliquely, axially conspicuously, broadly banded with chestnut, red and yellow, lineated with flesh colour—*"zebra"* Reeve.

(*b*) Closely undulately painted throughout with brown lines and with flesh-coloured flames beneath the sutures, and shorter than the typical, *"reticulata"* Reeve.

ORTHOMESUS ANGASI (Crosse)

Phasianella angasi Crosse 1864, Journ. de Conch., 344, pl. xiii, fig. 5.

Loc.—South Australia: Port Elliot (type loc.); both Gulfs; Beachport; Encounter Bay; Kangaroo Island; Port Lincoln; Yorke Peninsula; Point Sinclair; Venus Bay; Yankalilla Bay, 15 and 20 fms.; Rapid Head, 10 and 12 fms.; Hardwicke Bay, 8 and 10 fms.; Investigator Straits, 10, 15 and 20 fms.; Royston Head, 22 fms.; Wallaroo, 15 fms.; Yankalilla Bay, 12 fms., alive in shallow water and down to 22 fms. Western Australia: Bunbury; Ellenbrook; Rottnest; Albany; Yallingup; Esperance, Fremantle; Shark Bay; Carnarvon; Geraldton. Tasmania: North and West Coasts. Victoria: Western Port and Port Fairy.

Remarks—A very variable shell common at the type locality and vicinity, it is smaller than *rubens* Philippi which appears to be distributed in Northern Australia and the South Pacific, while *variegata* Lamarck is the Peronian species.

PELLAX GABINIANA Cotton and Godfrey 1938

Pellax gabiniana Cotton and Godfrey 1938, Rec. S. Aust. Mus., **6**, No. 2, 202, pl. xvii, fig. 12.

Loc.—South Australia: Yorke Peninsula; Royston Head (type loc.); Corny Point; Robe; Port Lincoln; Kangaroo Island. Victoria: Port Fairy. Western Australia: Albany; Rottnest.

Remarks—This species has been recorded from Southern Australia as *Phasianella kochi,* a South African shell, which is stouter and more solid in structure. The present species varies in colour pattern from the typical to the more common subsuturally axially flamed pattern, but all have the maculated band on the body whorl. Common in shell sand. Holotype, Reg. No. D.13414, S. Aust. Museum.

PELLAX TOMLINI (Gatliff and Gabriel)

Phasianella tomlini Gatliff and Gabriel 1921, Proc. Mal. Soc., Lond., **14**, 173, fig. 1, 2, 3.

Loc.—Western Australia (type loc.); Albany; Rottnest; Esperance; Hopetoun; King George Sound.

Remarks—The umbilical chink is closed in full adults. The shell differs from *gabiniana* in being more globose, spirally sculptured, thicker and with a different, contrasting, axial colour pattern. The comparison is made with paratypes of *tomlini* and holotype and paratypes of *gabiniana.*

Pellax johnstoni sp. nov.

Pl. xii, fig. 3, 4

Shell elongate oval, thin; whorls six, very slightly convex, smooth but for fine numerous sublenticular spiral striae; sutures linear, slightly descending at the aperture; aperture vertically ovate, slightly angulate above, outer lip simple, thin; inner lip simple, less curved than the outer lip, smooth, thickened, slightly excavate and scarcely effuse at the base; protoconch blunt, of two whorls, smooth, reddish-brown; body whorl with a white band below the suture, about one-fifth of the whorl, fading rapidly out anteriorly, crossed by nine axial brown bands, about one-half the width of their interspaces, slightly widening out at the anterior margin of the band; another white band gradually increasing in width anteriorly arises just below the angle of the aperture, and bounds the outer margin of the labium to the front edge of its effuse base, and is decorated throughout with oblique lines of reddish-brown spots. Height 6 mm., diameter 3·2 mm.

Loc.—Western Australia: Ellenbrook (type loc.); Hopetoun; Esperance. South Australia—Venus Bay.

Remarks—All specimens are typical and unlike any descriptions or figures of any allied species. Holotype, Reg. No. D14200. Named after Professor T. H. Johnston.

PELLAX VIRGO (Angas)

Eutropia (*Tricolia*) *virgo* Angas 1867, Proc. Zool. Soc., Lond., 115, pl. xiii, fig. 25.

Loc.—New South Wales: shell sand, Coogee Bay (type loc.); Port Jackson. South Australia: Guichen Bay; Robe.

Remarks—Rare in South Australia, only one or two specimens taken in the South-East.

PELLAX ROSEA (Angas)

Eutropia (*Tricolia*) *rosea* Angas 1867, Proc. Zool. Soc., Lond., 114, pl. xiii, fig. 24.

Loc.—New South Wales: shell sand Coogee Bay (type loc.); Port Jackson. South Australia: Beachport; Robe; MacDonnell Bay; numerous both Gulfs; St. Francis Island; dredged, Beachport, 40 fms.; Cape Borda, 55 fms.; Cape Jaffa, 130 fms., shallow water, alive down to 5 fms. Tasmania: general. Victoria: Western Port, Port Fairy. Western Australia: Yallingup; Ellenbrook; Hopetoun; King George Sound.

Remarks—Dredged specimens are buff-coloured. There are a number of variants amongst Southern Australian specimens, those from Rottnest being somewhat flattened, with waving axial colour flames.

(*a*) Unicoloured deep rose-red, typical.

(*b*) Distant, short, white narrow infrasutural flammules.

(*c*) Equally or less distant dead white streaks from the suture extending almost completely axially across the body whorl.

(*d*) Infrasutural flammules a spiral row of white spots well below the periphery, occasionally two rows, rarely joined with the infrasutural row by a white streak.

(*e*) More elongate, and whorls more convex.

(*f*) Body whorl somewhat flattened.

(*g*) A white line replaces the row of white dots below the periphery.

(*h*) Body whorl somewhat flattened, convex towards the base and with waving axials of red and white, best marked as crescents just below the suture and below the periphery, common at Rottnest.

(*i*) Zigzag flames of red joining upper with lower alternate red spots, with intercalating red flames from intermediate red spots, foundation colour of a faint tint.

GABRIELONA NEPEANENSIS (Gatliff and Gabriel)

Phasianella nepeanensis Gatliff and Gabriel 1908, Proc. Roy. Vict., 21, (2), 366.

Loc.—Victoria: Flinders; Western Port; Ocean Beach; near Point Nepean (type loc.). South Australia: Port Lincoln; Robe.

Remarks—I succeeded in finding only two specimens in shell sand at Port Lincoln in 1936 when on the McCoy Expedition, and one at Robe. Some of our specimens of *Pellax virgo* are hard to separate from *nepeanensis* and need very careful examination before certain identification.

Family COCCULINIDAE

NOTOCRATER TASMANICA (Pilsbry)

Acmaea tasmanica Pilsbry 1895, Nautilus, **8**, 128.

Loc.—Tasmania: Derwent Estuary, 10 fms. (type loc.), South and East in kelp roots. South Australia: Gulf St. Vincent, 10 fms.; St. Francis Island. Victoria: San Remo.

Remarks—*Notocrater meridionalis* Hedley 1903, from Port Kembla, New South Wales, 63 to 75 fms., is closely allied.

TECTISUMEN TASMANICA (May)

Cocculinella tasmanica May 1919, Proc. Roy. Soc. Tas., 67, pl. xvii, fig. 25, 25a.

Loc.—Tasmania: East Coast, 40 to 70 fms. (type loc.). South Australia: Cape Jaffa, 130 fms.

Remarks—The single South Australian specimen recorded by Verco in 1907 as *Cocculina coercita* Hedley 1906 is still unique. From a series of Tasmanian specimens I am inclined to think that the present species is close to *coercita* Hedley from east of Sydney in 300 fms. (type loc.), but Hedley's species is narrower, flatter, with an almost flat base, differences which may be detected in the adult but not so easily in younger specimens. The South Australian specimen is intermediate between *tasmanica* and *coercita,* but it is here placed as *tasmanica,* to which it bears closer resemblance, pending the discovery of further material. *Tectisumen compressa* Suter 1908, from New Zealand, is also closely allied.

TECTISUMEN MAYI Finlay

Tectisumen mayi Finlay 1926, Trans. New Zeal. Inst., **57**, 374.

Loc.—Tasmania: Schouten Island, 40 fms. (type loc.); Maria Island, 50 fms.; Port Arthur, 50 to 70 fms. South Australia: Beachport, 110 fms.

Remarks—This is the species recorded by May from Tasmania under the name *clypidellaeformis* Suter 1908, a New Zealand shell belonging also to the genus *Tectisumen* Finlay 1926.

Family LOTIIDAE

CONACMEA SUBUNDULATA (Angas)

Acmaea subundulata Angas 1865, Proc. Zool. Soc. Lond., 155.

Loc.—South Australia: Port Lincoln (type loc.); Normanville; Yankalilla Bay, American River, Kangaroo Island; Hardwicke Bay; both Gulfs; Robe; Port MacDonnell, Streaky Bay, Murat Bay, St. Francis Island, dredged alive at Kangaroo Island; Eastern Cove, 9 fms.; Rapid Head, 9 and 11 fms.; Gulf St. Vincent, off Glenelg, 7 fms., many alive. Victoria: Barwon Heads; Port Phillip; Cape Otway.

Remarks—Three specimens are before me which have been compared with the types in the British Museum and pronounced by Verco as typical. The holotype specimens and those before me represent the maximum adult size, the average being about 5 mm. x 7 mm. x 8 mm. and some apparently just adult being 4 mm. x 5 mm. x 6 mm. Verco correctly recorded this species as *subundulata* Angas 1906. *Notoacmea* (*Conacmea*) *alta* Oliver 1926 is a synonym, his figure and description agreeing perfectly with specimens compared with the types of *subundulata* except that his, like many South Australian examples, is smaller.

This species occurs alive in quantity in the meadows of short *Cymodocea* found on the lower parts of the sand flats exposed at low tide, such as at Outer Harbour, South Australia, the specimens being consistently small, and possibly juvenile.

Family CASSIDIDAE

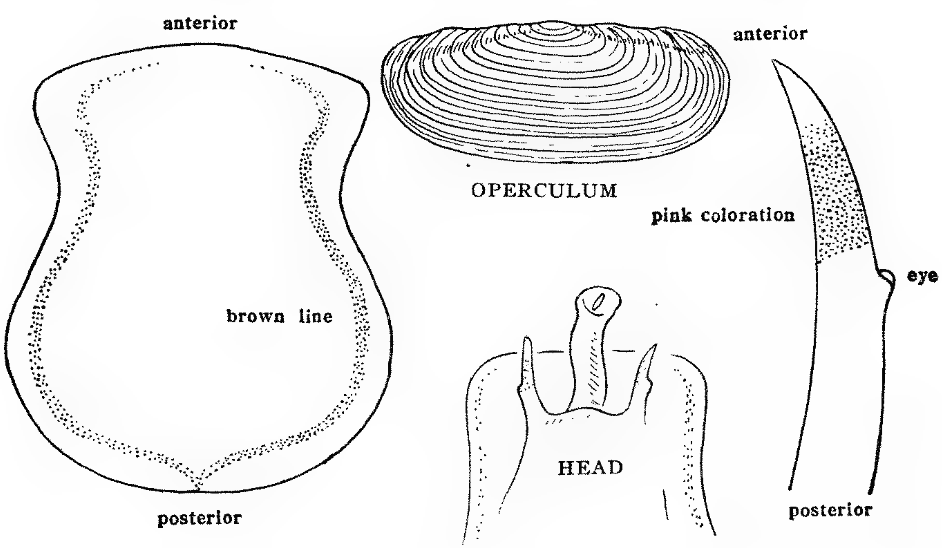
Hypocassis bicarinata (Jonas)

Cassis bicarinata Jones 1839, Archiv. Naturg., **1**, 343, pl. x, fig. 2.

Text fig.

Loc.—China (type loc., in error). South Australia: Gulf St. Vincent (type loc., designated); Minlacowie; Port Victor; Port Lincoln; American River; Lacepede Bay; common in both Gulfs; dredged Yankalilla Bay, 12 fms.; Rapid Bay, 9 fms.; Rapid Head, 10 to 12 fms.; Investigator Straits, 15 fms.; Middleton, 23 fms.; Troubridge, 19 fms., alive down to 20 fms., but rare. Victoria: Port Fairy.

Remarks—When young the shell has a denticulated inner margin to the outer lip, the teeth being well marked, numbering 15 to 16, the most anterior at the commencement of the canal, and the most posterior being the largest. Sometimes there is an additional small tooth behind the large posterior one. The large posterior tooth is opposite the second transverse row of tubercles, which is more or less apparent on the inner lip. In larger shells, say about two-and-a-half inches



FOOT TENTACLE

long, the outer lip is nearly or quite edentulous, but for the anterior or posterior teeth, and is much inflected. The young shell shows also longitudinal distant irregular, wavy or zigzag and even reticulated rusty lines. The animal has a large foot which is white, round behind, uniformly but less curved in front; on its upper surface is a brown line about two millimetres broad, complete posteriorly where it is produced to the edge. The tentacles are short, pointed, white at the distal ends and at the proximal half. The eyes are placed half-way down on the outer side, and just beyond these for one-half of the part distal to them the colour is pink. The under surface of the foot is quite white. There are varietal forms, micromorphs and macromorphs, which is not unusual in this family.

(*a*) Smaller closely wrinkled, low spired form, *"decresensis"* Hedley 1923, from Kangaroo Island.

(*b*) Thicker, smaller, heavier sculpture, spiral colour bands obsolete. This approaches *fimbriata* and is found rarely on the West Coast of South Australia.

(*c*) The typical *bicarinata* a large thinner shell, with subdued shoulder tubercles, irregular colour stripes of walnut brown, and the callus on the body whorl a mere glaze.

(*d*) A smaller dark-coloured form found in the sand amongst *Posidonia* weed.

The species is sometimes found in numbers on sandy beaches, 45 living specimens being counted by me at high tide mark on Sellicks Beach in 1935. The largest specimen measures 128 mm. in height and the average about 110 mm. for a fully grown adult.

HYPOCASSIS FIMBRIATA (Quoy and Gaimard)

Cassis fimbriata Quoy and Gaimard 1833, Voy. Astrolobe Zool., 2, 596, pl. xliii, fig. 7 to 8.

Loc.—Mariannes (type loc., error). Western Australia (type loc.): Albany; Esperance; Bunbury; Eyres Sand Patch; west of Eucla, 100 fms., alive.

Remarks—All our Western Australian specimens are much smaller than *bicarinata,* thicker and have wavy, axial, rust-coloured flames in the adult and juvenile, and the protoconch is larger, almost bulbous. They are consistently bicarinate with two rows of spiral sharp nodules. The 20 specimens before me show no intergradation, though a larger series might. The two specimens from 100 fms. are strongly bicarinate, one with a third weak carination below. This is the largest specimen I have seen and was recorded by Verco 1912 as "*fimbriata,*" measuring 83 mm. in height. The average would be about 70 mm.

XENOGALEA PAUCIRUGIS (Menke)

Cassis paucirugis Menke 1843, Moll. Nov. Holl. Spec., 23.

Loc.—Western Australia (type loc.); Albany, Esperance, Bunbury, beach and 22 fms. South Australia: Robe; Beachport, 100 fms.

Remarks—This species is represented from South Australia by a few beach-worn specimens and one dredged fragment.

Xenogalea mawsoni sp. nov.

Pl. xii, fig. 1, 2

Shell large, thin, globose oval, spire moderately exserted, aperture wide, external varix thin; colour when fresh pink-flesh tint with a blackish-purple on the varix of the canal and about seven blotches of black-purple on the outside of the recurved labrum, fading away towards the dorsum as vanishing spiral flames; some have two spiral bands of orange blotches on the body whorl; protoconch of two-and-a-half finely punctate whorls followed by finely spirally striate early whorls, later becoming smooth with two very weak and shallow spiral grooves; body whorl keeled at the shoulder with numerous small nodules, beneath which series is a shallow channel; there are close accremental striae throughout; canal short, recurved; columella not wrinkled, with a broad weak central fold; a deep gutter running into the wide umbilicus; outer lip with a thin, weakly developed varix, scarcely folded back and smooth, without internal lirae. Height 80 mm., width 55 mm.

Loc.—Western Australia: 120 miles west of Eucla, 120 fms. (type loc.), also 75 fms.; 90 miles west of Eucla, 85 and 100 fms.

Remarks—These specimens were recorded by Verco 1912, Trans. Roy. Soc. S. Aust., 217 under the name *Cassidea pyrum* Lamarck, but they are a very different species. The relationship is rather with *paucirugis,* but they are quite distinct. They are larger, thinner, differently sculptured and coloured and have a thin, scarcely reflected, non-lirate outer lip. The specimens are now faded

to almost dead white, but signs of the colour pattern can be faintly discerned. Holotype, Reg. No. D.14201, S. Aust. Museum. Named after Sir. D. Mawson.

Xenogalea denda sp. nov.

Shell, large, thin, globose, smooth; cream, with an extremely faint suggestion of rufous blotches; mouth white except on the lower outer lip, where there are pairs of chestnut blotches; body whorl smooth; outer lip narrowly reflected; columella with five weak plications above, then a narrow furrow followed by a strong fold running to the edge of the lobe. Height 82 mm., diameter 60 mm.

Loc.—Western Australia: Great Australian Bight, west of Eucla, 100 fms. (type loc.); also 250 fms.

Remarks—More globose than *stadialis* Hedley 1914, from between Gabo Island and Green Cape 50-100 fms., and practically without colour pattern.

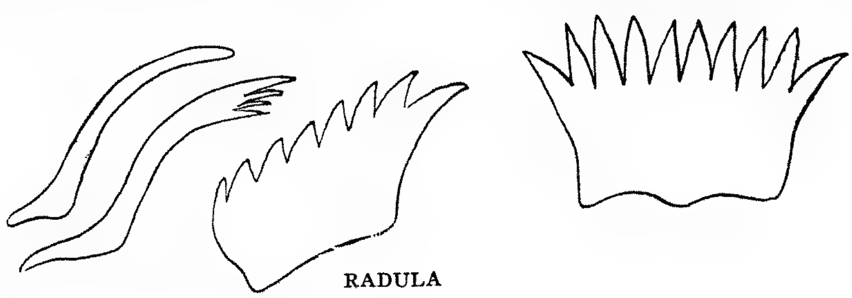
Holotype, Reg. No. D. 533, S. Aust. Museum.

ANTEPHALIUM SEMIGRANOSUM (Lamarck)

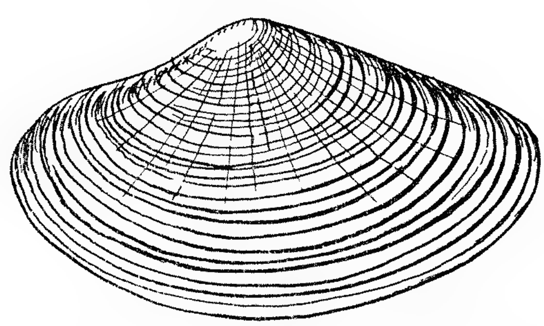
Text fig.

Cassis semigranosum Lamarck 1822, Hist. Anim. s. Vert., **7**, 228.

Loc.—Tasmania: South (type loc.). South Australia: Yankalilla Bay; Aldinga Bay; Encounter Bay; Pondolowie Bay; Lacepede Bay; dredged Yankalilla Bay, 15 fms.; Newland Head, 20 fms.; Beachport, 100, 110, 150 and 200 fms.; Cape Borda, 55 and 62 fms.; Cape Jaffa, 90 and 130 fms.; St. Francis Island,



RADULA



OPERCULUM

15 to 20 fms. Western Australia: 80 miles west of Eucla, 80 fms.; King George Sound, 12 and 35 fms.; Hopetoun, 35 fms.; Bunbury.

Remarks—All the dredged specimens are dead shells, some from 100 fms. having a longer protoconch. An occasional specimen has a kind of varix formed at a distance of half a whorl or less from the aperture, due to a reflected and thickened lip prematurely formed. The radula teeth and operculum are figured here.

ANTEPHALIUM ADCOCKI (Sowerby)

Cassis adcocki Sowerby 1896, Proc. Mal. Soc. Lond., **2**, 14, text fig.

Loc.—South Australia: Yankalilla Bay (type loc.); Kingscote; Troubridge (Riddle); Normanville; Port Morowie; Port Elliot; Beachport, 40 fms. (fragment). Western Australia: 90 miles west of Eucla, 100 fms.

Remarks—The largest specimen I have seen, 42 mm. in height, is in G. Pattison's Collection, taken at Troubridge.

Family VOLUTIDAE

MELO MILTONIS (Gray)

Pl. xiii

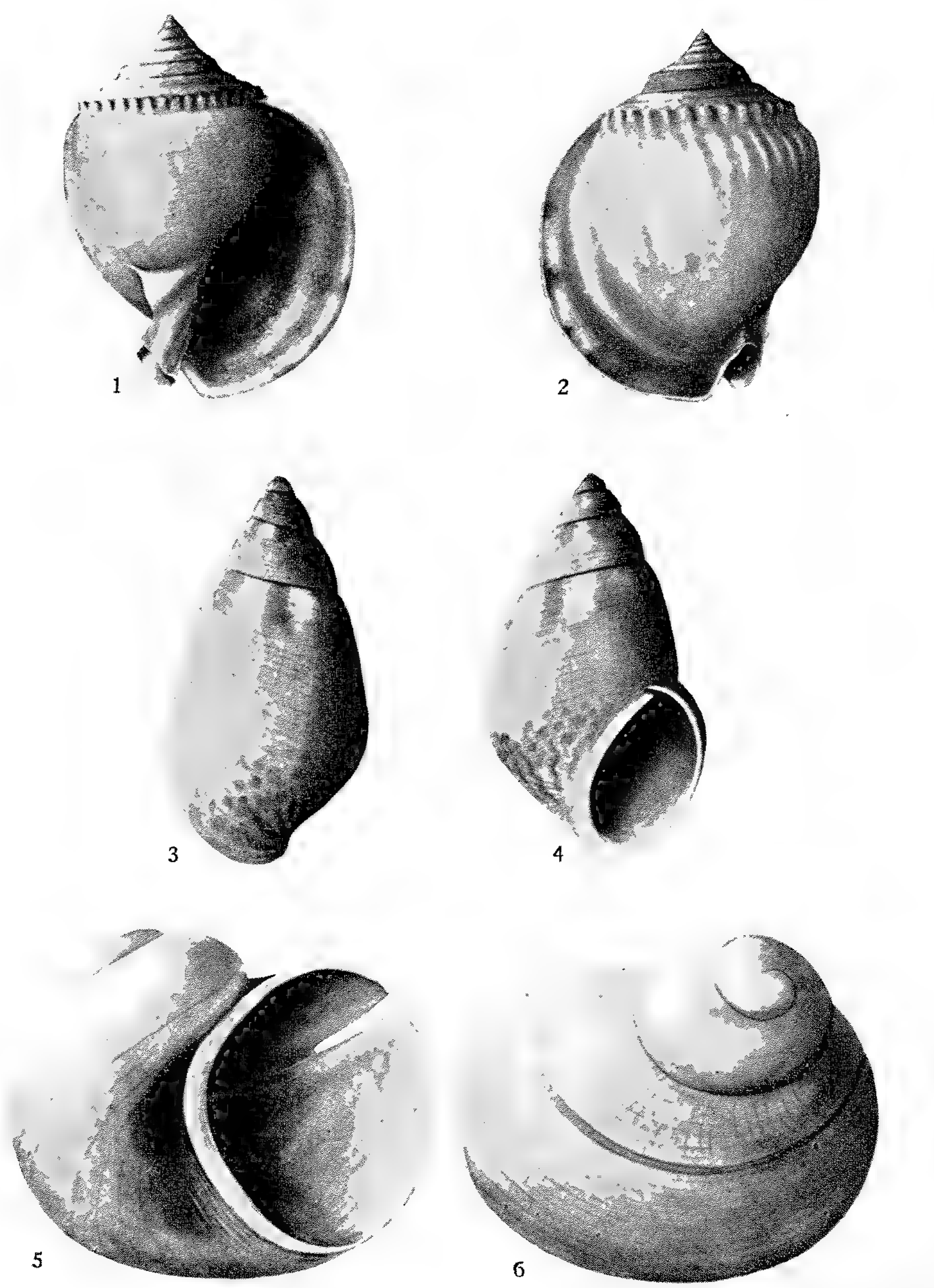
Voluta miltonis Gray 1833, Griffiths Animal Kingdom, **12**, Mollusca, pl. xxix.
Cymbium miltonis Gray, Kuster 1841, Conch. Cab., **5**, (2), 213, pl. xlii, fig. 1.
Voluta miltonis Deshayes, Anim. Sans Vert., 2nd edit., **10**, 406, sp. 46.
Melo miltonis Gray, Broderip, Thes. Conch., **1**, 415, sp. 7, pl. lxxxiii, fig. 24, 25.

Loc.—South Australia: Cape Thevenard; Murat Bay; Streaky Bay; Fowlers Bay; St. Peters Island; Laura Bay; Eyre Island; Cape Vivonne. Western Australia: 90 miles west of Eucla, 60 miles off shore, 95 fms.; Eucla, 90 fms.; King George Sound.

Remarks—The original figure in Griffith and Pidgeon (Griffith's Edition of Cuvier's Animal Kingdom) is not very good, but there is no other Melon shell at all like this species and Broderip 1855 reduced his *cylindratus* to a synonym. Reeve 1861, Conch. Icon., **13**, pl. xvi, fig. 8 a and b, shows a typical specimen from Swan River, Western Australia, not unlike that of Griffith and Pidgeon's. Sowerby Thes. Conch., **1**, pl. lxxxiii, fig. 24 and 25, gives accurate figures of a specimen from the same locality like that figured by the writer from Cape Thevenard, in Rec. S. Aust. Mus., **5**, (4), 506, fig. 1 and 2. A specimen taken alive at St. Peters Island has a big muscular fleshy foot, light chocolate coloured, veined with cream and the upper parts of the body cream-coloured. A photograph of the animal just emerging from the shell is reproduced here (pl. xiii). The shell is 260 mm. in height and 160 mm. wide. During and between the months of September to December the Baler congregates in groups of 40 to 50 in certain definite areas on our west coast, when egg-laying takes place. The males and females have shells of slightly different size and shape, which has led some to think that there are two species of Baler along our coast. Queensland species are *umbilicatus* Sowerby 1825, Gen. Moll., pl. ccliv, a wide-mouthed form, closely coronate, with spikes incurved, based on a Moreton Bay shell; the commoner *georginae* Gray 1833, originally named from a Swan River shell, and the closely allied *mucronatus* Sowerby 1847 from Moreton Bay.

SUMMARY

The exact geographical and vertical localities of 77 South Australian Gastropods are given. One new genus, *Eudaronia,* and four new species, *Scissurona vincentiana, Pellax johnstoni, Xenogalea mawsoni* and *X. denda* are described. Many variations of the typical shell and observations on the living animal and radula are also given.



Gwen D. Walsh

Fig. 1 and 2 *Xenogalea mawsoni* sp. nov., x 0·6 3 and 4 *Pellax johnstoni* sp. nov., x 8
5 and 6 *Scissurona vincentiana* sp. nov., x 8

Melo miltonis Gray, animal emerging from the shell, x 0·38

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AUSTRALIAN CUMACEA NO. 11 THE FAMILY DIASTYLIDAE (PART 1)

BY HERBERT M. HALE, DIRECTOR, SOUTH AUSTRALIAN MUSEUM

(READ 14 JUNE 1945)

Summary

The Australian Diastylid fauna, as collected to date, presents a facies very different from that of the Arctic, Subarctic and Boreal regions; the Cumacea of the Antarctic and Subantarctic are as yet not very well known.

While more than 40 Australian species are now in hand, mainly from off the southern and eastern coasts, two-thirds of them belond to *Gynodiastylis* and allied genera, where the reduction of parts is carried further than anywhere else within the family. These last are dealt with in another place. The other species are referred to four genera which may be separated as follows:-

1. Adult male with basis of peraeopods not greatly expanded, and with flagellum of second antenna short. *Leptostylis* Sars.
   Adult male with basis of first to fourth peraeopods greatly expanded and with flagellum of second antenna reaching at least to end of pleon. 2
2. Third maxilliped of female without exopod. *Paradiastylis* Calman.
   Third maxilliped of female with exopod. 3
3. Pleopods each with two rami, furnished with plumose setae. Female with no trace of exopods on third and fourth peraeopods. *Dimorphostylis* Zimmer
   Pleopods each with only one ramus, furnished with modified, non-plumose setae. Female with small exopods on third and fourth peraeopods. *Anchistylis* gen. Nov.

AUSTRALIAN CUMACEA No. 11 [1]
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By HERBERT M. HALE, Director, South Australian Museum

[Read 14 June 1945]

Fig. 1-26

INTRODUCTION

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While more than 40 Australian species are now in hand, mainly from off the southern and eastern coasts, two-thirds of them belong to *Gynodiastylis* and allied genera, where the reduction of parts is carried further than anywhere else within the family. These last are dealt with in another place. The other species are referred to four genera which may be separated as follows:—

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Third maxilliped of female with exopod. 3

3 Pleopods each with two rami, furnished with plumose setae. Female with no trace of exopods on third and fourth peraeopods. .... *Dimorphostylis* Zimmer
Pleopods each with only one ramus, furnished with modified, non-plumose setae. Female with small exopods on third and fourth peraeopods. *Anchistylis* gen. nov.

The three last-named genera present points of interest when compared to the *Gynodiastylis* group. In *Paradiastylis* the exopod of the third maxilliped of the female is consistently absent, in some species of *Dimorphostylis* it is rather small in this sex. In *Dimorphostylis vieta* the pleopod is somewhat more rudimentary than in other species referred to the genus. The post-anal part of the telson is short or insignificant in both sexes of *Paradiastylis* and *Dimorphostylis australis* Foxon, and also in the females of *Dimorphostylis asiatica* Zimmer, *D. vieta* (Hale), *D. colefaxi* sp. nov. and *Anchistylis*. The three genera are outstanding in that they have the basis of all but the last of the peraeopods of the adult male conspicuously expanded, distally produced, and furnished with exopods having the peduncle very broad; these wide thoracic exopods are strikingly different from those of *Gynodiastylis*, etc., where the specialized second antenna of the male and the complete absence of pleopods provide good distinguishing features. Also worthy of attention is the telson of *Dimorphostylis australis*, where, while there is no distinct post-anal part, the somite is very long and cylindrical, a feature paralleled in the genotype of *Dic* (Stebbing, 1910, p. 415), *Makrokylindrus* (Stebbing 1912, p. 150) and in Calman's *Diastylis tubulicauda* and *D. fistularis* (Calman, 1905, p. 46 and 1911, p. 383; see also Zimmer, 1914, pp. 191-193).

Another point of interest is the fact that the branchial leaflets where examined in both *Dimorphostylis* and *Anchistylis* are digitiform and few in number, usually about ten or so in both sexes.

Finally, the pleopods of *Anchistylis* exhibit a departure from the usual type.

[1] No. 10, see Trans. Roy. Soc. S. Aust., 69, (1), 86-95.

Genus Leptostylis Sars

Leptostylis Sars, 1869, p. 343; Stebbing 1913, p. 123 (ref.); Hansen 1920, p. 71; Hale 1928, p. 47.

Key to Australian Species of Leptostylis

Carapace covered with spinules. .... *vercoi* Hale
Carapace smooth. .... *recalvastra* sp. nov.

Leptostylis recalvastra sp. nov.

Ovigerous female—Integument thin, semi-transparent, slightly calcified and clothed with scattered but quite prominent hairs.

Carapace two-sevenths of total length of animal and more than twice as long as pedigerous somites together; seen from above it is subtriangular in shape, broadest at rear end, where it is almost as wide as long and nearly half as wide

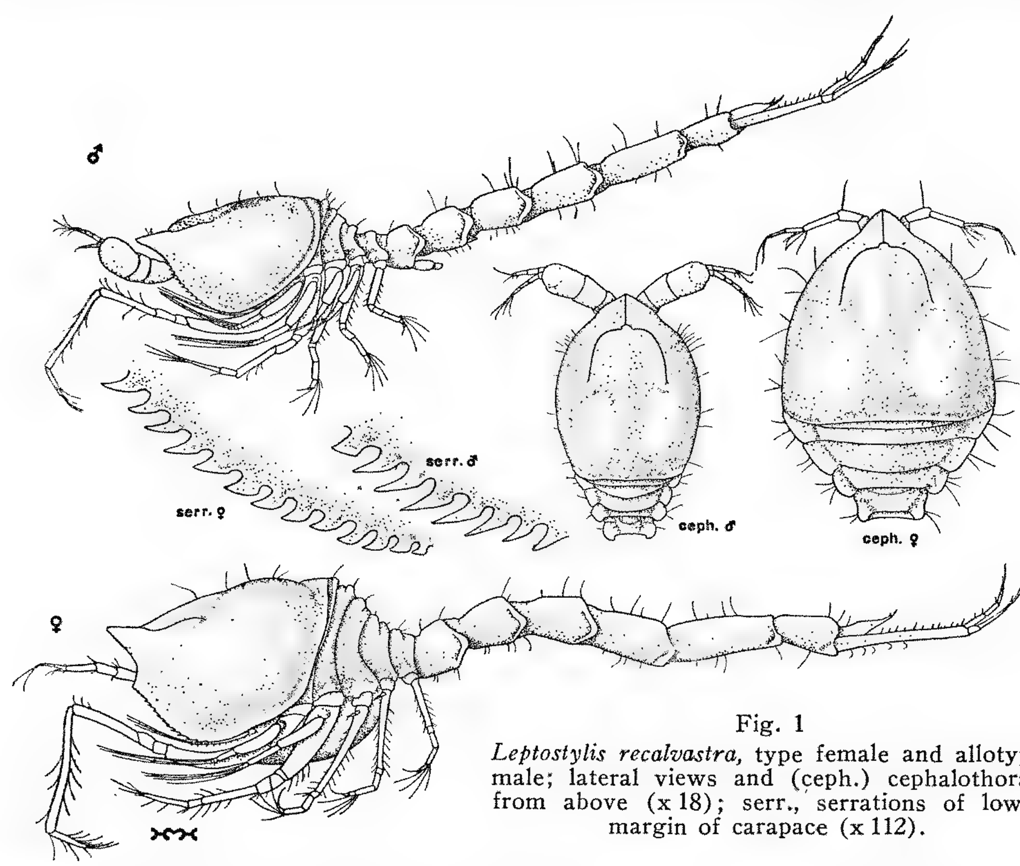

Fig. 1
Leptostylis recalvastra, type female and allotype male; lateral views and (ceph.) cephalothorax from above (x 18); serr., serrations of lower margin of carapace (x 112).

again as deep; seen from the side the upper profile is somewhat sinuate because of the swollen branchial regions, between which the dorsum is sulcate; there is a low boss on each side of frontal lobe at posterior end of sutures and outside the latter is a low fold, but the sides are without ridges or other sculpture save for faint pitting. Pseudorostrum subacute in front, the lobes meeting for a distance equal to one-sixth of length of carapace. Ocular lobe very small, unarmed, rounded, and without apparent lenses. Antero-lateral margin very shallowly concave, antero-lateral angle obtuse, and inferior margin posterior to it serrate, the teeth varying as shown in fig. 1.

Pedigerous somites each with a transverse fold; first partly concealed, the rest not differing much in length and not greatly expanded on sides.

Pleon half as long again as cephalothorax; fifth somite narrowing slightly to the rear, subcylindrical, as wide as deep and nearly three times as long as breadth; sixth somite only half as long as fifth and distinctly dilated posteriorly: telson about as long as sixth somite, armed with a pair of rather long apical spines and with a single pair of lateral spines; about one-fourth of its length is post-anal.

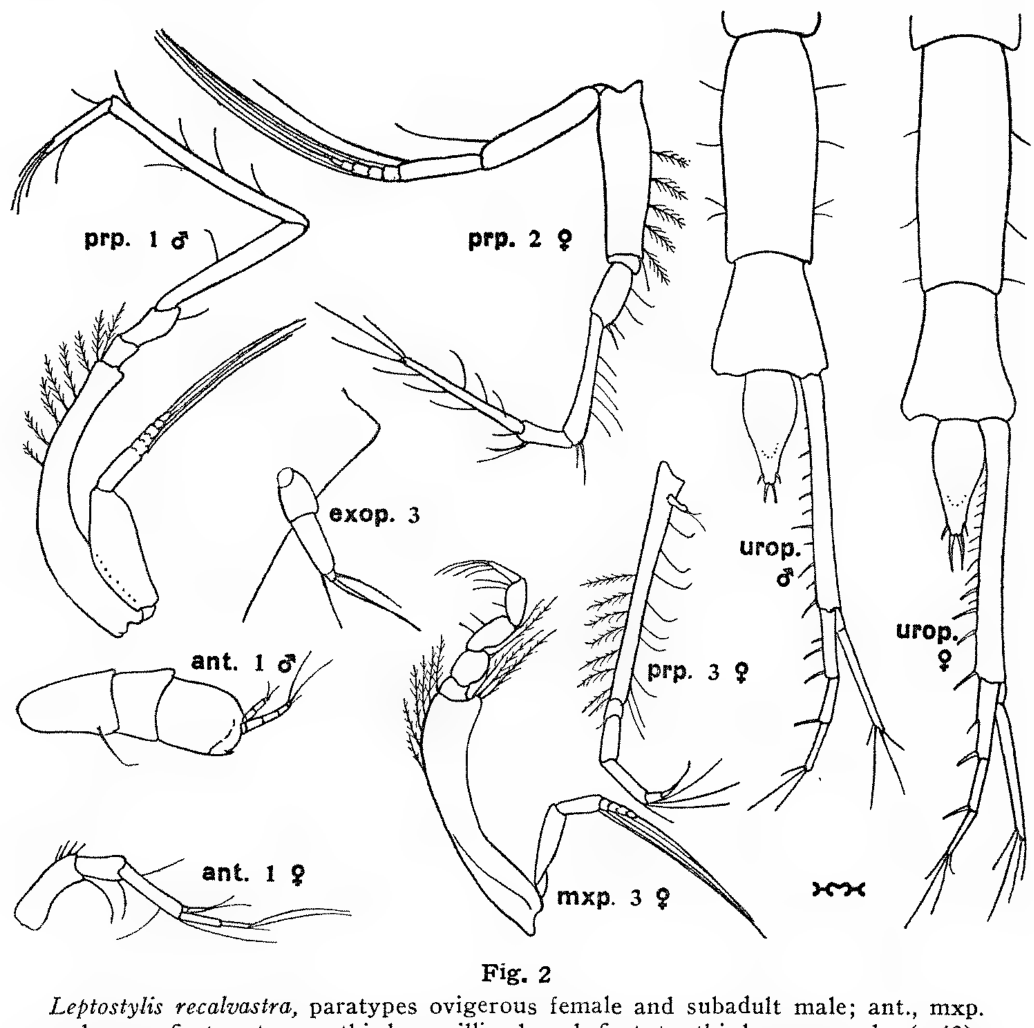

Fig. 2

Leptostylis recalvastra, paratypes ovigerous female and subadult male; ant., mxp. and prp., first antenna, third maxilliped and first to third peraeopods (x 43); exop. 3, exopod of third peraeopod (x 180); urop., uropod with fifth to sixth pleon somites and telson (x 43).

First antenna with first and third joints of peduncle subequal in length, each considerably longer than second; flagellum composed of two subequal joints, which together are almost as long as last segment of peduncle; accessory lash shorter than first joint of main flagellum, also two-jointed but with the first segment very short.

Mandible with ten or eleven spines, the anterior eight or nine of which are stout.

Third maxilliped slender, the basis nearly half as long again as rest of limb; merus, carpus, propodus and dactylus subequal in length.

First peraeopod long, the carpus reaching well beyond level of end of pseudo-rostrum; basis only about half as long as remaining joints together, propodus nearly two-thirds as long again as carpus and almost three times as long as dactylus.

Basis of second peraeopod only half as long as rest of limb; ischium distinct; carpus twice as long as merus, a little more than twice as long as propodus, and equal in length to the long dactylus.

Third and fourth peraeopods with basis longer than rest of limb and with merus shorter than carpus; propodal seta and longest carpal setae reaching well beyond tip of the slender dactylus; exopods three-jointed (the last segment minute) and furnished with three setae; fifth peraeopod with basis not longer than remaining joints together.

Peduncle of uropod distinctly more than twice as long as telson, the inner margin with a dozen irregular spines; endopod two-thirds as long as peduncle, three-jointed; first segment one-third as long again as second and with two spines on inner margin; second joint with one inner spine at distal end; third joint not quite as long as second and without spines on inner margin.

Length, 5·4 mm. Embryo, with pleon curved, 0·28 mm. Ova approximately 0·2 mm.

Subadult male—Carapace suboval in shape as viewed from above, widest at about middle of length, where it is less than one-third as broad again as depth; it is about two-sevenths of total length, and more than twice as long as pedigerous somites together; the antennal angle is not at all marked but the inferior margin is serrate (see fig. 1, serr. ♂); frontal lobe, etc., as in female.

Pleon fully half as long again as cephalothorax; telson and uropods as in adult female.

First antenna relatively very large, the last joint of peduncle globose, but the long hairs have not yet appeared; flagellum five-jointed, the first and last joints short, the others subequal in length; accessory lash four-jointed, and as long as first three segments of main flagellum; the proximal and distal joints are small, the other two elongate.

Length, 4·5 mm.

Loc.—New South Wales: four miles off Eden, 70 metres, in silt (allotype male, K. Sheard, Oct. 1943); five miles off Eden, 60 metres, on mud (type female, K. Sheard, submarine light, Dec. 1943); four miles east of Port Hacking, 80 metres, on mud (K. Sheard, A. Trawl, May 1944). Types in S. Aust. Museum, Reg. No. C. 2762-2763.

A second ovigerous female taken with the type is slightly smaller. Only immature males are available; in these the first pleopod, though still without setae, is large, but the second quite rudimentary.

This species in some respects closely resembles the Subarctic *gracilis* Stappers (male only—1908, p. 100, pl. i-iii), but differs in the slightly different proportions of the uropods, the much shorter basis of the first peraeopod, and the very large male first antenna.

Genus PARADIASTYLIS Calman

Paradiastylis Calman 1904, p. 173, and 1905a, p. 20, and 1911, p. 366; Zimmer, 1908, p. 181, etc., and 1936, p. 435; Stebbing, 1912, p. 146, and 1913, p. 121; Kemp, 1916, p. 398.

Two species are now recorded for Australia. *P. tumida* Hale (1937, p. 66, fig. 3) proves, by acquisition of the adult male, to belong elsewhere.

Key to Species of Paradiastylis

1 Each side of carapace with at most one ridge. Distal end of male telson spiniform and without articulated terminal spines. .... *culicoides* Kemp

Each side of carapace with at least three oblique ridges. Distal end of male telson not spiniform and with a pair of articulated spines. 2

2 First joint of endopod of uropod twice as long as second and third joints together. *brevicaudata* (Zimmer)

First joint of endopod of uropod not longer than second and third joints together. 3

3 Peduncle of uropod much longer than combined lengths of sixth pleon somite and telson. .... *longipes* Calman

Peduncle of uropod not longer than sixth pleon somite and telson together. 4

4 Each side of carapace with four oblique ridges. Propodus of first peraeopod short, not as long as merus and carpus combined. Propodus of second peraeopod three-fourths as long as either dactylus or carpus. .... *brachyura* Calman

Each side of carapace with three oblique ridges. Propodus of first peraeopod elongate, considerably longer than merus and carpus combined. Propodus of second peraeopod only half as long as dactylus and much less than half as long as carpus. .... *mollis* sp. nov.

Paradiastylis longipes Calman

Paradiastylis longipes Calman 1905a, p. 21, fig. 4; Stebbing, 1913, p. 122 (ref.).

A single male from New South Wales (Cronulla, 8 feet, K. Sheard, Sept. 1942) departs from Calman's description in small details. The size is a trifle larger (3·7 mm.) but the body and appendages are just as described, except that the uropod differs in having 13 or 14 instead of about 20 inner spines, and in having the endopod relatively shorter; this has the joints armed with five, three and three inner spines respectively, but the first segment is relatively shorter, so that the ramus as a whole is not much longer than the exopod and is less than half as long as the peduncle. The integument, as stated by Calman, is membranous, and the three lateral ridges of the carapace are detected with difficulty; in the example in hand these are less oblique than shown in Calman's figure. The U-shaped ridge on the dorsum of the telson is pronounced and the short post-anal portion has a pair of apical spines, on each side of which are a shorter spine and a seta.

The species was previously known only from north of the Equator, in Malayan waters. Possibly the Australian form represents another species, but as the male now recorded agrees so closely in most details with that of *longipes* one hesitates to separate it on the grounds mentioned.

Paradiastylis mollis sp. nov.

Ovigerous female—Integument membranous; fragile and transparent.

Carapace ovate in shape as seen from above, wider than deep, about two-thirds as long again as deep; it is one-third of the total length of animal and twice as long as pedigerous somites together; each side has three oblique, curved ridges, the most anterior distinct, the others faintly defined; posterior half of dorsum with a deep and wide median gutter; the mid-line, as seen from the side, is excavate at the front of the first of the ridges and again (where it is armed with a small tooth) midway between this and the ocular lobe. Pseudorostrum sub-acute in front, one-fifth of total length of carapace. Ocular lobe moderately large, more than twice as wide as long, with no apparent lenses, but with a small tooth on each side; antero-lateral angle scarcely at all excavate and angle not defined.

First pedigerous somite partly concealed; fourth dorsally much the longest, as long as combined dorsal lengths of first to third somites.

Pleon not much longer than cephalothorax; fifth somite subcylindrical, twice as long as wide and almost twice as long as the sixth somite, which is not markedly dilated posteriorly; telson subcordate, as long as sixth somite, with short post-anal portion, armed with a pair of apical spines and two pairs of lateral spines, anterior to which are two pairs of short bristles.

Third segment of peduncle of first antenna one-fourth as long again as second; flagellum not much shorter than second peduncular segment and composed of two equal joints; accessory flagellum unisegmentate, nearly half as long as main lash. Second antenna four-jointed, the last segment minute, the third and fourth subequal in length.

Mandible with nine or ten spines, the last two of which are slender, the others unusually robust.

First peraeopod long, the carpus reaching almost to level of end of pseudo-rostrum; basis short, not greatly more than one-third as long as rest of limb and

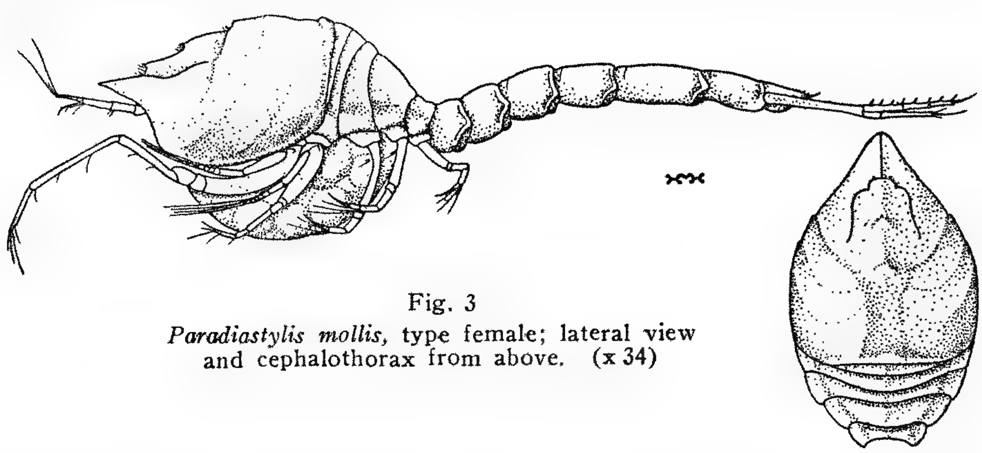

Fig. 3
Paradiastylis mollis, type female; lateral view and cephalothorax from above. (x 34)

not quite as long as propodus, which is almost half as long again as carpus and fully twice as long as dactylus.

Basis of second peraeopod also relatively short, not longer than rest of limb without dactylus; ischium distinct; carpus longer than dactylus (but shorter than dactylus plus propodus), twice as long as merus and nearly three times as long as propodus; longest dactylar setae equal in length to dactylus.

Basis of third peraeopod not as long as rest of limb, merus distinctly longer than carpus, and dactylus long and slender; fourth peraeopod little shorter than third, and fifth not much smaller than fourth; the propodal seta and two slender distal carpal setae in all the posterior legs reach beyond the tip of dactylus.

Uropod with peduncle twice as long as telson and armed on inner margin with nine or ten spines which successively increase in length in distal half; endopod not much shorter than peduncle, three-jointed, the first segment not quite twice as long as second which is barely as long as third; inner spines are respectively four, two and two, and the slender distal spine is equal in length to the third joint; exopod equal in length to the first two segments of endopod, with the longer of the distal spines two-thirds as long as the ramus.

Length, 2·58 mm. Ova, 0·164 mm. to 0·176 mm.

Loc.—Queensland: Moreton Bay, Myora Bight, surface (I. S. R. Munro, Stations 29 and 45, 50 cm. 40 m. net, 3.30 a.m. and 10.30 p.m., 29 Nov. 1940). Type in S. Aust. Museum, Reg. No. C.2765.

Another female has an extra spine on second joint of endopod of uropod. In this species the peduncle of this appendage is much shorter than in *longipes* Calman, being only twice as long as the telson, as in *brachyura* Calman (1904, p. 174, pl. v, fig. 76-90); the last-named species, however, has the rami shorter in relation to the peduncle and the exopod little shorter than the endopod, the second segment of which is longer than the third according to Calman's figure,

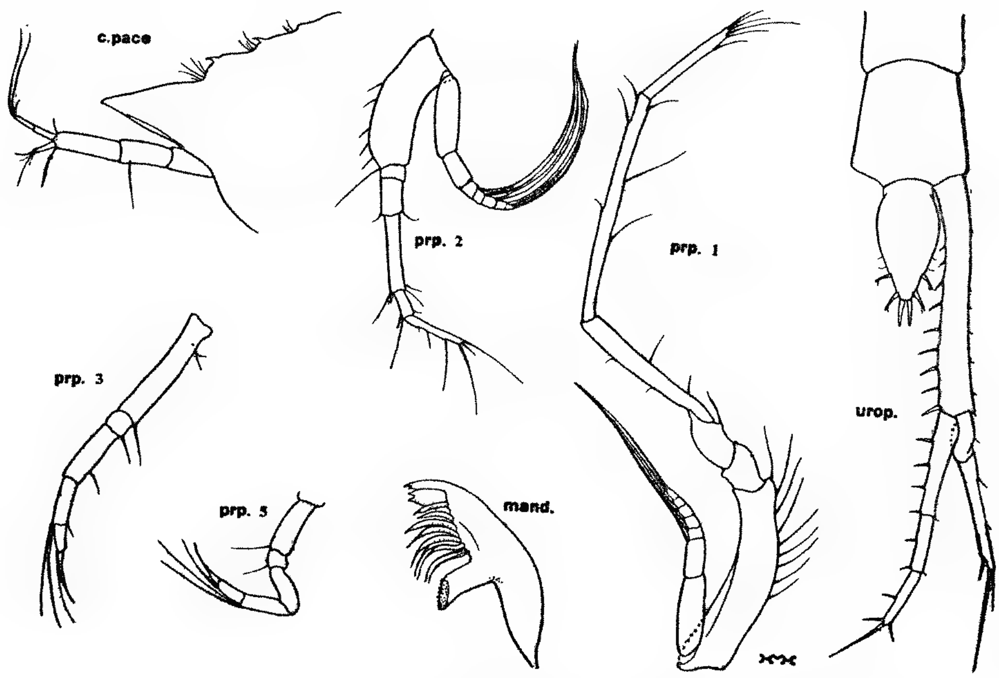

Fig. 4
Paradiastylis mollis, type female: c pace, anterior portion of carapace and first antenna (x 75); mand., mandible (x 125); prp., first, second, third and fifth peraeopods (x 75); urop., uropod with sixth pleon somite and telson (x 75).

while the very different proportions of the joints of the first and second peraeopods, the shorter carpal and propodal setae of the posterior legs, and the presence of four ridges on each side of the carapace provide other differences.

Genus Dimorphostylis Zimmer

Dimorphostylis Zimmer 1921, p. 144, and 1936, p. 435; Foxon, 1932, p. 390; Hale, 1936, p. 403.

If Zimmer's genotype material is all referable to the one species this is unusual in the very marked differences between the telson of female and adult male. What is more extraordinary is the fact that in the young male the telson has no distinct post-anal part (as in the young female) but that this appears in the adult male.

Examination of the Australian Diastylids so far in hand and, as previously noted, representing upward of 40 species, forces one to the conclusion that the relative length, and armature, of the post-anal part of the telson cannot be regarded as reliable generic characters; this is discussed under the genus *Gynodiastylis*, which is dealt with in another paper. The species now placed in *Dimorphostylis* differ so much in this respect that the generic name becomes apt in still another direction! (see Zimmer *ut supra*, p. 148).

As Zimmer himself states, the genus is close to *Paradiastylis;* broadening the diagnosis to admit Foxon's *australis, cottoni* Hale, and the new species described below, it differs only in having an exopod on the third maxilliped of the female. The males of both *Dimorphostylis* and *Paradiastylis* are distinguished from *Diastylis* by the expanded basis of the peraeopods, but the inclusion in the first-named genus of species with two instead of three terminal spines on the telson makes it difficult to find characters to separate males of this genus from those of *Paradiastylis.* Difficulties arise also if females alone are concerned; in the present case *colefaxi* sp. nov. is referred here rather than to *Diastylis* only because in *Dimorphostylis,* as in *Gynodiastylis,* etc., there is a tendency towards extreme reduction of the post-anal part of the telson.

Exopods are entirely absent on the third and fourth peraeopods of the females of the species now dealt with; in this detail they are distinct from the forms placed in *Leptostylis.* The males, where known, have the flagellum of the second antenna longer than is recognised for *Leptostylis.*

Key to Species of Dimorphostylis

1 Preanal portion of telson much longer than sixth pleon somite .... *australis* Foxon
Preanal portion of telson shorter than sixth pleon somite. 2

2 Sides of carapace covered with short spines. .... *subaculeata* sp. nov.
Carapace not spiny or with spines confined to anterior portion. 3

3 Each lateral margin of telson with a non-articulated tooth. 4
Lateral margins of telson entire (articulated spines or bristles present). 5

4 Carapace with distinct lateral carinae posterior to level of frontal lobe. Basis of second peraeopod shorter than rest of limb, with a strong distal tooth; ischium and merus of this limb also with inner teeth. Second segment of endopod of uropod shorter than third. .... *inauspicata* sp. nov.
Carapace with no distinct carinae posterior to level of frontal lobe. Second peraeopod without teeth, its basis as long as rest of limb. Second segment of endopod of uropod longer than third. .... *tasmanica* sp. nov.

5 First segment of endopod of uropod not much longer than second. *vieta* (Hale)
First segment of endopod of uropod longer than second and third segments together. 6

6 Carapace with low folds but no clear-cut ridges. First peraeopod short, with propodus not as long as carpus. .... *colefaxi* sp. nov.
Carapace with sharply defined lateral ridges. First peraeopod long, with propodus much longer than carpus. 7

7 Carapace with at least four carinae on each side, between hinder end of frontal lobe and posterior margin. Carpus of second peraeopod distinctly longer than combined lengths of propodus and dactylus .... *cottoni* Hale
Carapace with three carinae on each side between hinder end of frontal lobe and posterior margin. 8

8 Carpace without spines. Telson of young male and female with no distinct post-anal part and no lateral spines. Carpus of second peraeopod not much longer than merus. .... *asiatica* Zimmer
Anterior part of carapace with spines; first lateral carina spiny. Telson of female with distinct post-anal part, armed with lateral spines. Carpus of second peraeopod almost twice as long as merus. .... *tribulis* sp. nov.

Dimorphostylis australis Foxon

Dimorphostylis australis Foxon 1932, p. 390, fig. 7-8.

Foxon's specimens were secured by the Great Barrier Reef Expedition at Low Isles, Queensland (lat. 16° 23′ S.). Males occur in material from several of Mr. I. S. R. Munro's stations in Moreton Bay (lat. 27° 18′ S.), and it is possible to supplement the brief description of that sex.

Adult male—Integument membranous, transparent.

Carapace more than twice as long as pedigerous somites together, one-third of total length of animal (one-fourth in female, *fide* Foxon), considerably wider than deep and twice as long as greatest depth; seen from the side its dorsum is but slightly arched; from above its greatest width occurs at the level of ocular lobe; sides with three faintly defined, oblique, and forwardly curved ridges, not meeting on dorsum but separated by a wide longitudinal gutter. Antero-lateral margin oblique, very slightly sinuate, and antero-lateral angle widely rounded, not dentate. Pseudorostrum narrowly truncate as viewed from above, subacute as seen from the side; lobes meeting for a distance equal to one-sixth of total length of carapace. Ocular lobe large, rounded, very slightly constricted at base, twice as wide as long and with three large, unpigmented, corneal lenses.

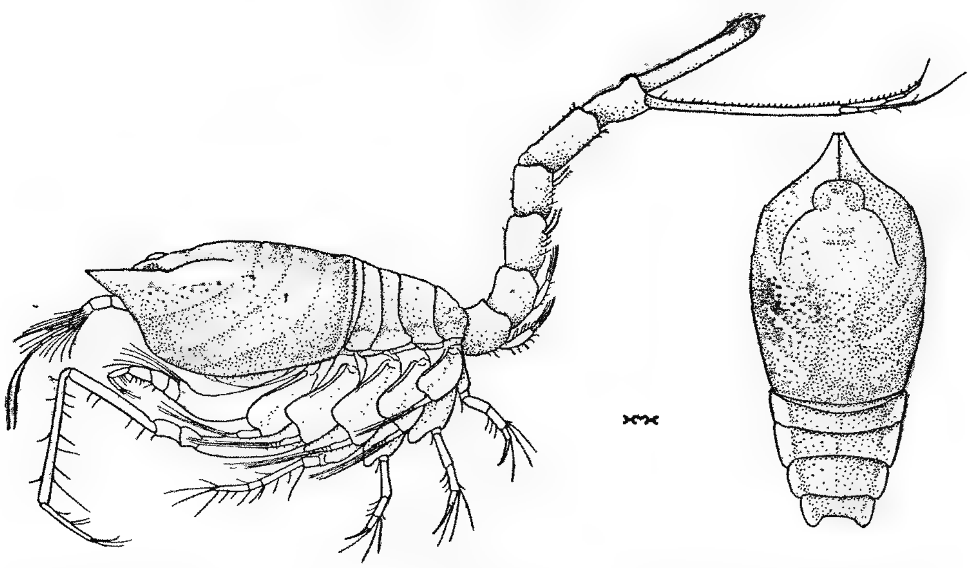

Fig. 5
Dimorphostylis australis, adult male; lateral view and cephalothorax from above (x 20).

First pedigerous somite very short; fourth a little longer than any of the others; pleural parts not greatly dilated, but third expanded both fore and aft.

Pleon longer than cephalothorax by half the length of telson; fifth somite subcylindrical, half as long again as wide and one-fourth as long again as sixth somite, which is slightly broadened posteriorly, where it is as wide as long; on each side of distal end of ventral gutter of third and fourth somites there is a pair of strong setae, plumose for part of their length; the almost cylindrical telson is fully as long as fifth and sixth pleon somites together, more than four times longer than greatest width, without any post-anal part, and with a pair of tiny dumb-bell-shaped terminal spines, flanked on each side by a bristle; in posterior third the dorsum is marked by a depression, with a U-shaped raised margin.

First antenna with first joint longer than third, which is distinctly longer than second and is furnished with a brush of dense sensory hairs, emanating from an oval area occupying the greater part of length on one side; flagellum as long as second and third peduncular joints together, four-jointed, the first segment very short, the second longer than subequal third and fourth combined; accessory lash more than half as long as main flagellum, four-jointed, the proximal and distal segments short and second segment shorter than third, which is about half the length of the whole flagellum.

Second antenna with flagellum reaching at least to end of peduncle of uropod, sometimes to distal ends of rami of that appendage.

Third maxilliped with the dilated basis half as long again as rest of limb, the segments of which successively increase in length to the propodus, which is half as long again as dactylus.

First peraeopod elongate, the carpus reaching to level of tip of pseudo-rostrum; basis half as long as rest of limb with the usual distal brush of finely plumose setae; propodus nearly half as long again as carpus and distinctly more than twice as long as dactylus.

Second peraeopod with basis, including distal lobe, longer than remaining joints together; carpus as long as propodus and dactylus together and more than twice as long as merus.

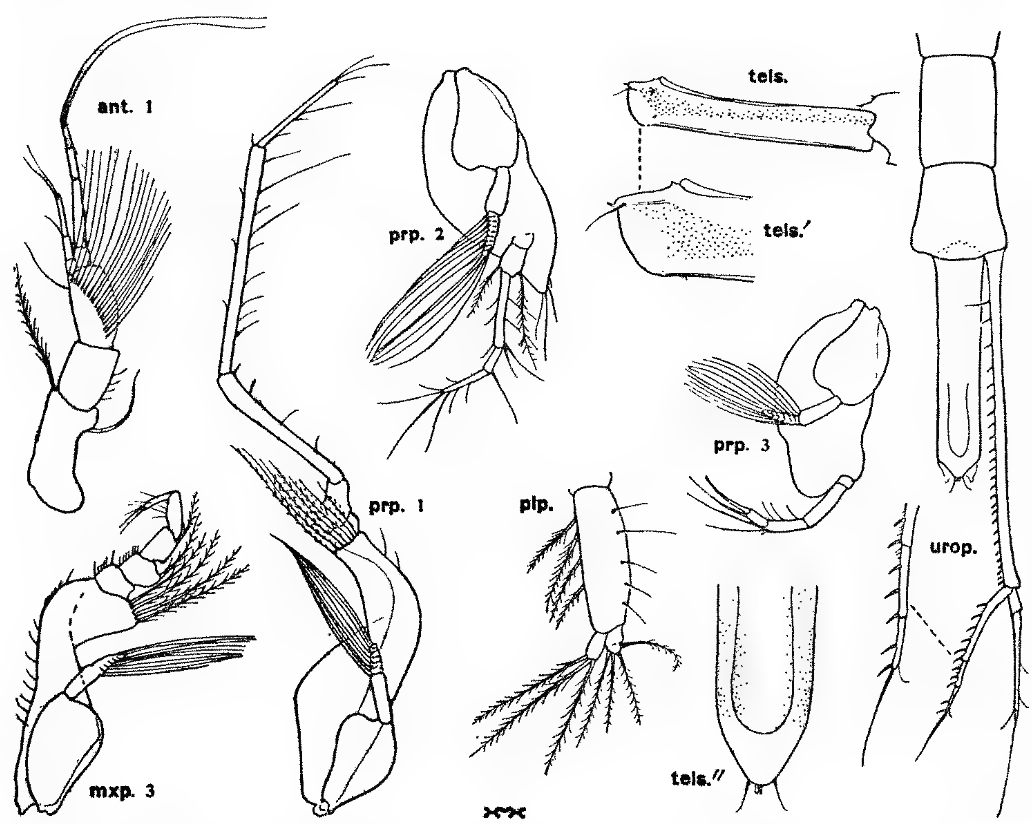

Fig. 6

Dimorphostylis australis, adult male; ant., first antenna (x 65); mxp. and prp., third maxilliped and peraeopods (x 34); plp., pleopod (x 90); urop., uropod with fifth to sixth pleon somites and telson (x 34; distal joints of endopod, x 65).

Basis of third and fourth peraeopods about as long as rest of limb, that of fifth much shorter; merus in all posterior legs shorter than carpus and propodus together; longest carpal and propodal setae reaching a little beyond tip of dactylus.

Peduncle of pleopods robust; rami small, the exopod indistinctly two-jointed.

Peduncle of uropod fully half as long again as telson, more than two and one-third times as long again as endopod, and with about 25 short spines on inner margin, preceded by a bristle; endopod with first joint more than half as long again as second and third segments together, and with second joint one-third as long again as third; inner spines are usually six plus three plus two and the slender terminal seta is as long as the last two joints together; exopod a little

shorter than endopod, with the long distal seta not much shorter than the second joint of the ramus.

Length, 4·9 mm. to 5 mm.

Dimorphostylis subaculeata sp. nov.

Ovigerous female—Integument thin, but calcified and firm. Armed with spinules, which are numerous and closely set on carapace.

Carapace robust, one-third of total length of animal, twice as long as deep, and fully half as wide again as deep; seen from above the sides are subparallel in posterior half, tapering rapidly to the front; the branchial regions are swollen and between them the dorsum is sulcate; there is a deep pit on each side of rear end of frontal lobe. Pseudorostrum subacute in front, the lobes meeting for a distance equal to almost one-fifth of length of carapace. Antero-lateral margin very shallowly concave; antennal angle rounded and, like inferior margin, spinulose. Ocular lobe rounded, more than twice as wide as long, spinulose but without apparent lenses.

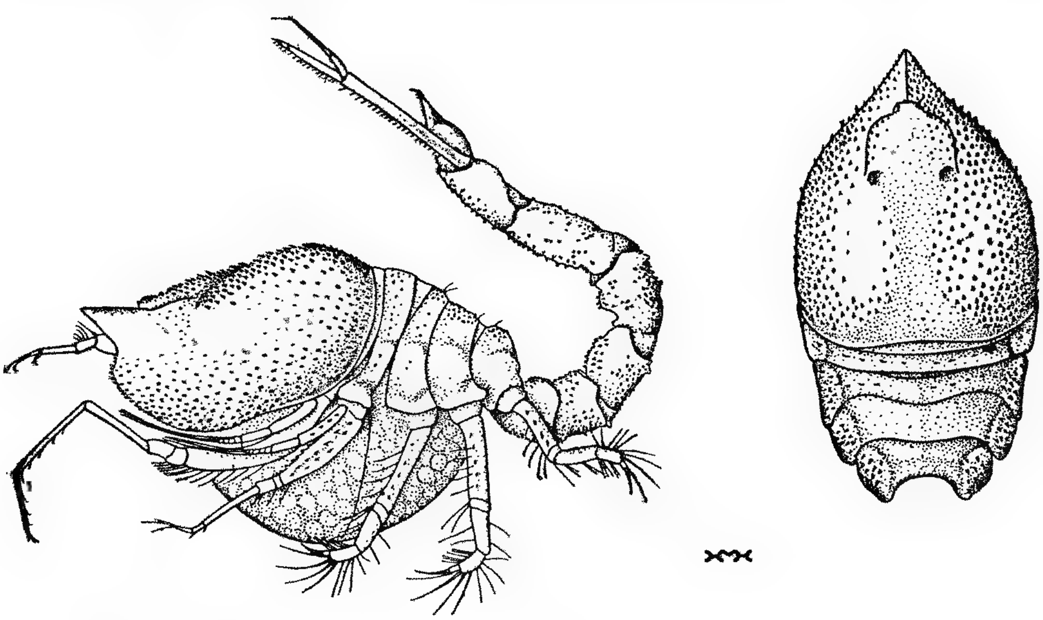

Fig. 7

Dimorphostylis subaculeata, type female; lateral view and cephalothorax from above (x 9).

Pedigerous somites together more than half as long as carapace; first partly concealed; fourth and fifth dorsally longer than second or third; pleural parts not greatly expanded, but second and third legs a little more widely separated than the others.

Pleon about as long as cephalothorax; fifth somite subcylindrical, slightly narrowed towards distal end and fully one-third as long again as sixth somite, which is somewhat expanded posteriorly, where it is almost as wide as long; telson not much shorter than sixth somite, with two-fifths of its length post-anal; it is armed with a pair of short, stout, terminal spines and two pairs of lateral spines, anterior to which on each side is a row of short bristles.

First antenna with first segment of peduncle a little longer than third and half as long again as second; the flagellum is composed of two subequal joints,

is half as long as the last peduncular joint, and fully twice as long as the three-jointed accessory lash, which has the proximal and distal segments very short.

Second antenna four-jointed; the first segment bears two long plumose setae, the second and third joints each one similar seta and the short, conical, terminal segment one plain seta.

Mandible with 19 to 20 spines in the row (fig. 9 A).

First maxilliped with 10 digitiform gill-lobes. Third maxilliped with exopod more than half as long as the basis, which is twice as long as remaining joints together, and has the external distal angle rounded, not forwardly produced or expanded, and furnished with a fan of half-a-dozen plumose setae; ischium with a tooth at outer distal angle; carpus and propodus subequal in length, each a little longer than either merus or dactylus.

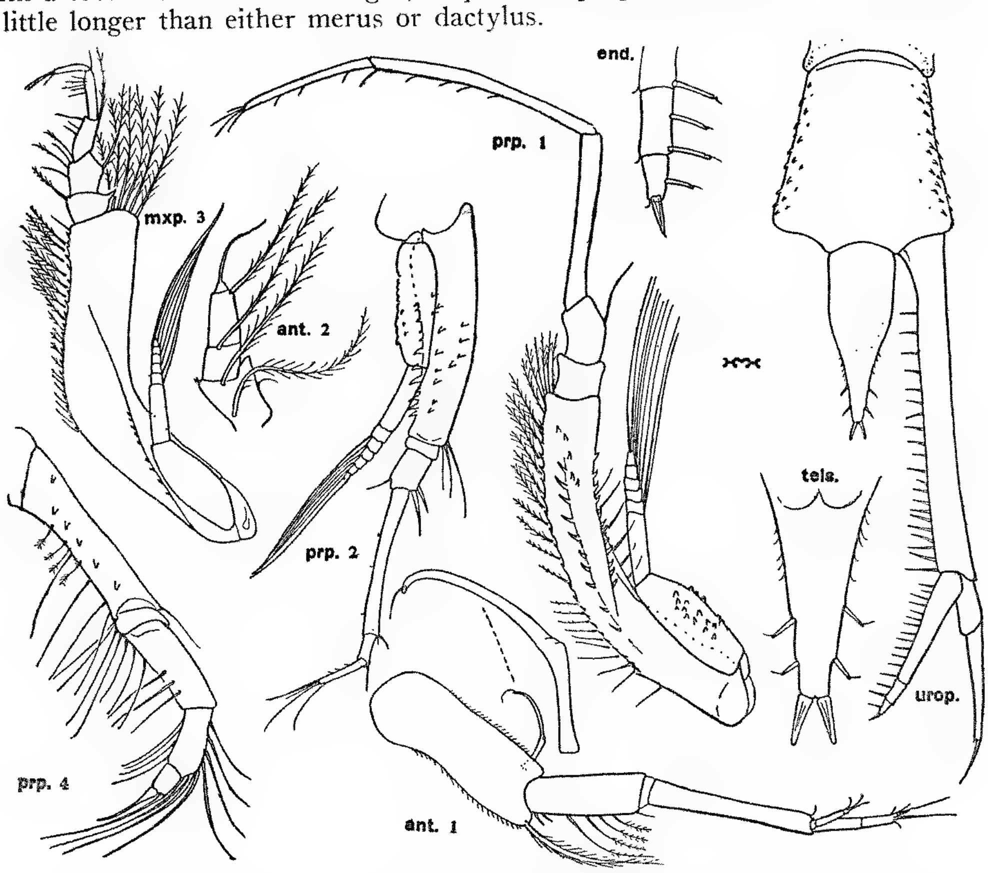

Fig. 8

Dimorphostylis subaculeata, type female; ant., first and second antennae (x 44; seta, x 135); mxp. and prp., third maxilliped, first, second, and fourth peraeopods (x 22); urop., uropod with sixth pleon somite and telson (x 22); tels., post-anal portion of telson (x 55); end., distal joint of endopod of uropod (x 60).

First peraeopod long, the carpus reaching just beyond antero-lateral angle of carapace; basis spinose, not dilated, less than two-thirds as long as rest of limb; propodus fully as long as merus and carpus together, and three-fourths as long again as dactylus.

Basis of second peraeopod shorter than rest of limb by the length of dactylus; ischium distinct, relatively large; carpus slender, more than three times as long as merus and fully four times as long as propodus, which is not much more than half as long as the dactylus.

Third to fifth peraeopods stout, with numerous long setae; basis (as in second) spinose, in the third and fourth pairs about as long as rest of limb without dactylus, in the fifth shorter than this; merus quite as long as carpus and propodus together; dactylus long and slender; the outer face of carpus bears near distal end three stout setae (preceded by four or five more slender setae), and these, together with propodal seta, form a stout rake which extends well beyond tip of dactylus.

Peduncle of uropod twice as long as telson and fully twice as long as the rami, which are equal in length; its inner margin bears 19 to 21 spines; endopod three-jointed, the first segment fully three times as long as the combined lengths of the last two joints, the second not quite half as long again as the short terminal joint; inner spines of the respective segments, on both endopods, are twelve plus two plus one and the terminal spine, much stouter than the others (fig. 8, end.) is not as long as the distal joint; exopod with two terminal spines, one minute, the other less than one-third as long as the ramus.

Colour white. Length, 12·1 mm. Embryos in marsupium very numerous, small in relation to size of animal and, with pleon curved against back, 0·34 mm. to 0·39 mm. in length.

Loc.—Tasmania: Marion Bay, 10-17 fms., amongst kelp (W. S. Fairbridge, Euphausiid bottom net, Dec. 1944). Type in S. Aust. Museum, Reg. No. C. 2745.

Dimorphostylis subaculeata var. **praecox** nov.

Ovigerous female—Armature of body and proportions of body and segments of appendages as in Tasmanian form. Differs in the smaller size and in having fewer spines in the mandible row (13 to 14) and a lesser number of spines arming the inner margins of peduncle and endopod of uropod. In the type, 8·8 mm. in length, these number 13 on peduncle and six plus two plus one on the endopodal joints. The largest ovigerous females are 9·3 mm. in length and have 17 spines on the peduncle, and on the endopod seven or eight plus two plus one.

Young females—The spines of the carapace are sparser than in the adult, and there are fewer inner spines on the uropod. It is evident that in the case of the female the spines of this appendage increase more or less regularly in number as the animal grows. The smallest available example is 4·6 mm. in length and has the peduncle of the last-named appendage armed with only nine spines, that of endopod with three plus two plus one. In a subadult female 7 mm. in length the armature is much as in the type. The telson has about one-third of its length post-anal even in the young and bears one or two pairs of lateral spines (rarely there is a third spine on one side, fig. 9, urop. ♀); this variation has no relation to the size of the animal.

Embryos in the marsupium are the same size as those of the large Tasmanian female.

It would seem that this form, which was taken in waters slightly warmer than those of Marion Bay, the Tasmanian type locality, passes through fewer ecdyses before becoming ovigerous.

Adult male—Integument less calcified than in female; spiny armature sparser and tending on sides of carapace to become blunted.

Carapace only about two-sevenths of total length of animal, two-thirds as long again as pedigerous somites, more than twice as long as deep and half as broad again as deep; seen from above it is suboval, tapering to the front in anterior third. Pseudorostrum subacute in front, the lobes meeting for a distance equal to little more than one-sixth of length of carapace. Antero-lateral margin oblique, slightly sinuate, scarcely at all excavate; no antennal angle, the margin

forming a wide curve to the inferior edge, which is finely spinulose. Ocular lobe rounded, larger than in female, more than twice as wide as long and with three prominently raised but colourless corneal lenses.

Pleon, not including telson in the length, as long as cephalothorax; fifth somite narrowed slightly towards the rear, and half as long again as sixth, which is less widened posteriorly than in female; telson as long as sixth somite, with a pair of stout terminal spines and two pairs of much smaller lateral spines.

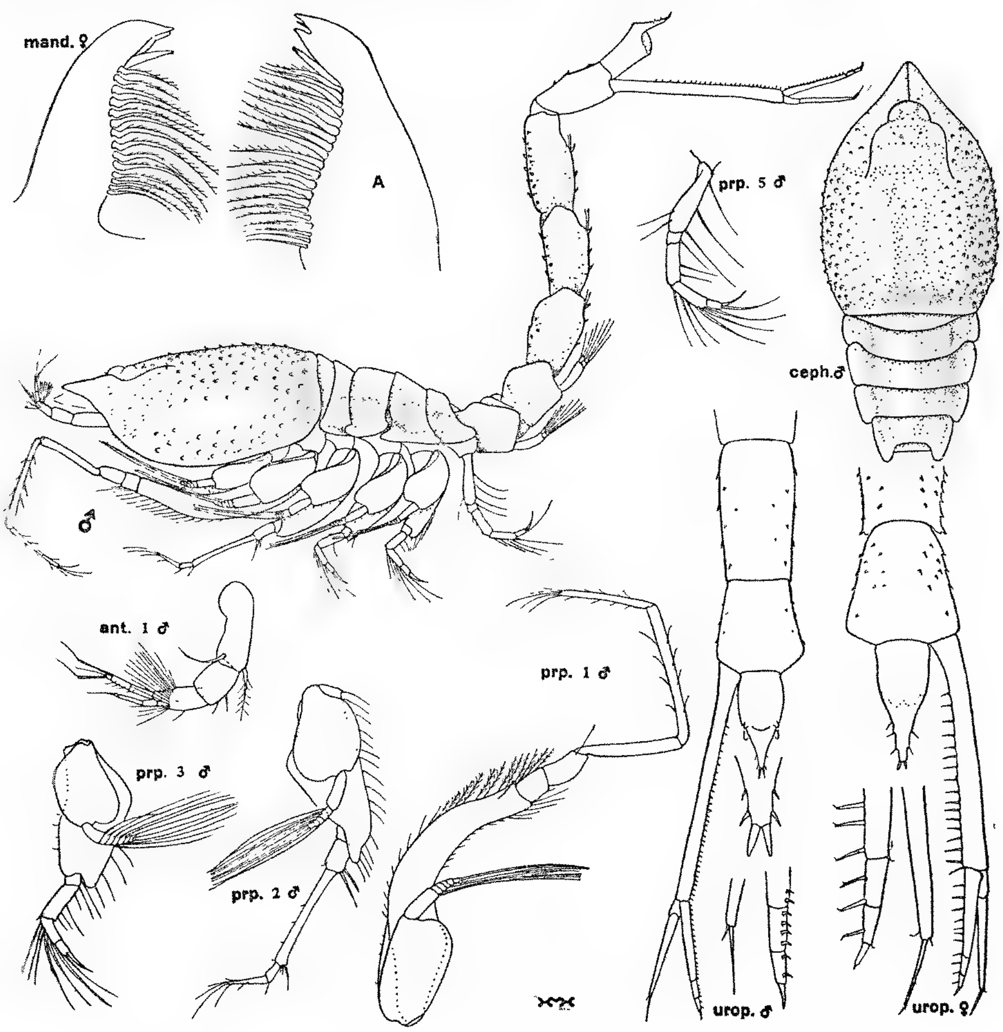

Fig. 9

Dimorphostylis subaculeata, var. *praecoxa*, adult male and 9·3 mm. ovigerous female; lateral view of male and (ceph.) cephalothorax from above (x 12); ant., first antenna (x 30); mand., distal portion of mandible (x 80; A, mandible of Tasmanian type ovigerous female for comparison, x 80); prp. and urop., peraeopods and uropod with telson, etc. (x 20; distal parts of rami of uropod, x 52).

First antenna stouter than in female; first peduncular joint nearly twice as long as either second or third segments, which are subequal in length; third not much narrower than second and furnished with a dense brush of sensory setae; flagellum one-third as long again as last peduncular segment, four-jointed, the distal and proximal joints very short, the other two subequal in length; accessory lash as long as distal joint of peduncle, four-jointed, the third segment much the

longest and the terminal one minute. Second antenna with flagellum reaching to end of pleon.

Mandibles with 11 to 12 spines in the row.

First peraeopods relatively a little longer than in female, the carpus reaching slightly beyond level of end of pseudorostrum; basis two-thirds as long as rest of limb; proportions of other joints as in female, save that the dactylus is a trifle longer.

Basis of second peraeopod, including distal lobe in the length, shorter than remaining joints together; ischium distinct; other segments as in female excepting that dactylus is slightly longer.

In the third and fourth peraeopods the wide basis is fully as long as the rest of limb, the setae of which are as in female; fifth peraeopod about three-fourths as long as fourth, with the narrow basis only two-thirds as long as rest of limb.

Peduncle of uropod slender, two and one-half times as long as telson and distinctly more than twice as long as endopod; its inner margin bears thirty or more spines, much shorter than those of female; endopod exceeding exopod in length by almost the length of its distal joint; first segment fully two-and-one-half times as long as second and third together; second joint less than half as long again as third; inner spines 16, plus three or four, plus two; terminal spines of both rami as in female.

Both pairs of pleopods biramous, the exopod two-jointed.

Colour, semi-transparent. Length, 9 mm.

An adult male, 8 mm. in length and taken in company with females at Ulladulla, has the spines on the inner margin of the three endopod joints of the uropod twenty-two plus five plus two.

Subadult males have the carapace shaped more as in the young females, with similar armature and with about the same number of spines (longer than in adult male) on the uropods. An example 8·1 mm. in length (with the setae of the pleopods and exopods of third and fourth peraeopods very short) has only about 17 spines on the peduncle of this appendage and nine plus two plus one on the endopod. This example has the basis of the peraeopods a trifle wider than in the adult female, but not greatly expanded and distally produced as in the adult male.

Loc.—New South Wales: off Jibbon, on sand, 35 fms. (K. Sheard, submarine light, 1940); Cronulla, 8 feet on sand (K. Sheard, submarine light, Sept. 1942); off Jibbon, 50 metres on sand (dredged, K. Sheard, June 1943), and 40-70 metres, on sand (K. Sheard, A. Trawl Station 6, 9 and 10, July-Aug. 1943); off Ulladulla, 75 metres (K. Sheard, A. Trawl, June 1944). Types in S. Aust. Museum, Reg. No. C. 2754 and 2767.

This species resembles the Western Australian *Leptostylis vercoi* (Hale 1928, p. 47, fig. 17), which, like other members of its genus, has small exopods on the third and fourth legs of the female; the appendages show relatively slight differences, in the uropods, for instance, the peduncle is a little shorter, and the first joint of the endopod is only twice as long as second and third segments together.

Dimorphostylis inauspicata sp. nov.

Subadult male—Integument thin, not much calcified, but tough and not easily torn.

Carapace one-third of total length of animal and twice as long as pedigerous somites together; it is a little wider than deep and almost half as long again as deep; each side with four ridges curving obliquely forwards; the most anterior ridge is short and serrate and arises near posterior end of frontal suture; the second, more feebly serrate, commences near the mid-line and terminates close to

the upper part of first; it is almost joined near mid-line by a fainter carina which in turn is met by the fourth; in addition to these a short, sinuate, serrate ridge arises near end of pseudorostrum, curves backwards and downwards, and is continued as a much fainter carina, subparallel to inferior margin and reaching to hinder edge; anterior half of carapace from ocular lobe to branchial regions is elevated medianly, the rounded ridge sinuate as viewed from the side and armed with three small teeth, one at base of ocular lobe and two (one behind the other) at rear end of frontal lobe; there is also a pair of tiny denticles on the ocular lobe; the lateral ridges are somewhat broken and this, together with the slight depressions between them, results in an irregularity of the outline of the sides when the animal is viewed from above; branchial regions somewhat elevated dorsally, leaving between them in posterior half of carapace a rather deep sulcus; pseudorostrum depressed, each lobe with a small point anteriorly; lobes meeting for a distance equal to about one-sixth of length of carapace; antero-lateral margin

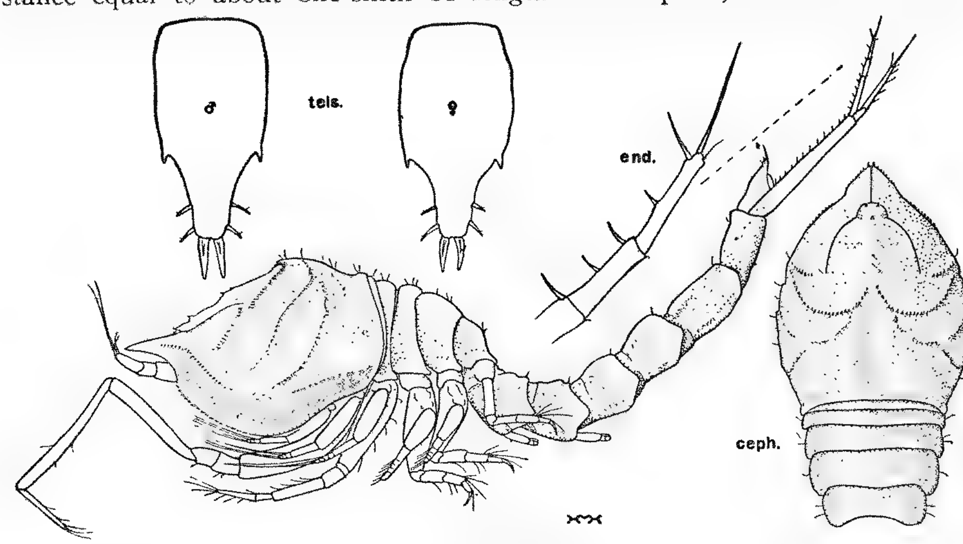

Fig. 10

Dimorphostylis inauspicata, type male; lateral view and (ceph.) cephalothorax from above (x 16½); end., distal joints of endopod of uropod (x 80); tels., telson of paratype male and allotype female (x 56).

very shallowly concave; antero-lateral angle rounded and, like inferior margin posterior to it, finely serrate; ocular lobe rounded, twice as wide as long, with faint indications of eye-spots.

Pedigerous somites successively increasing in dorsal length to fourth, which is a little longer than fifth; each is marked with a fine median dorsal line and has the pleural parts not much expanded.

Pleon fully as long as cephalothorax; somites one to five with a dorso-lateral and infero-lateral carina on each side, the lateral space between them concave; sixth somite depressed, keeled laterally, slightly widened posteriorly and about four-fifths as long as fifth; telson four-fifths as long as sixth somite, with a small tooth beyond middle of length of each lateral margin and with only a short post-anal portion, armed with a pair of terminal spines and two pairs of lateral spines.

Antennae not fully developed. First segment of peduncle of first pair twice as long as second joint, longer than the swollen third, and with a distal spine, as well as the usual stout seta and plumose seta; each flagellum four-jointed, the main lash half as long again as the other and as long as third peduncular joint.

Mandible with 13 to 14 spines.

Third maxilliped with basis quite half as long again as rest of appendage, with a tooth at inner distal angle and margin posterior to this in part serrate; ischium and merus each with an inner tooth.

First peraeopod long, the carpus reaching beyond level of end of pseudo-rostrum; basis relatively short, not quite half as long as rest of limb; propodus almost equal to combined lengths of ischium, merus and carpus, and a little more than twice as long as dactylus.

Basis of second peraeopod broad (presumed to be forwardly produced distally in adult), serrate on inner edge and with a large tooth, preceded by a

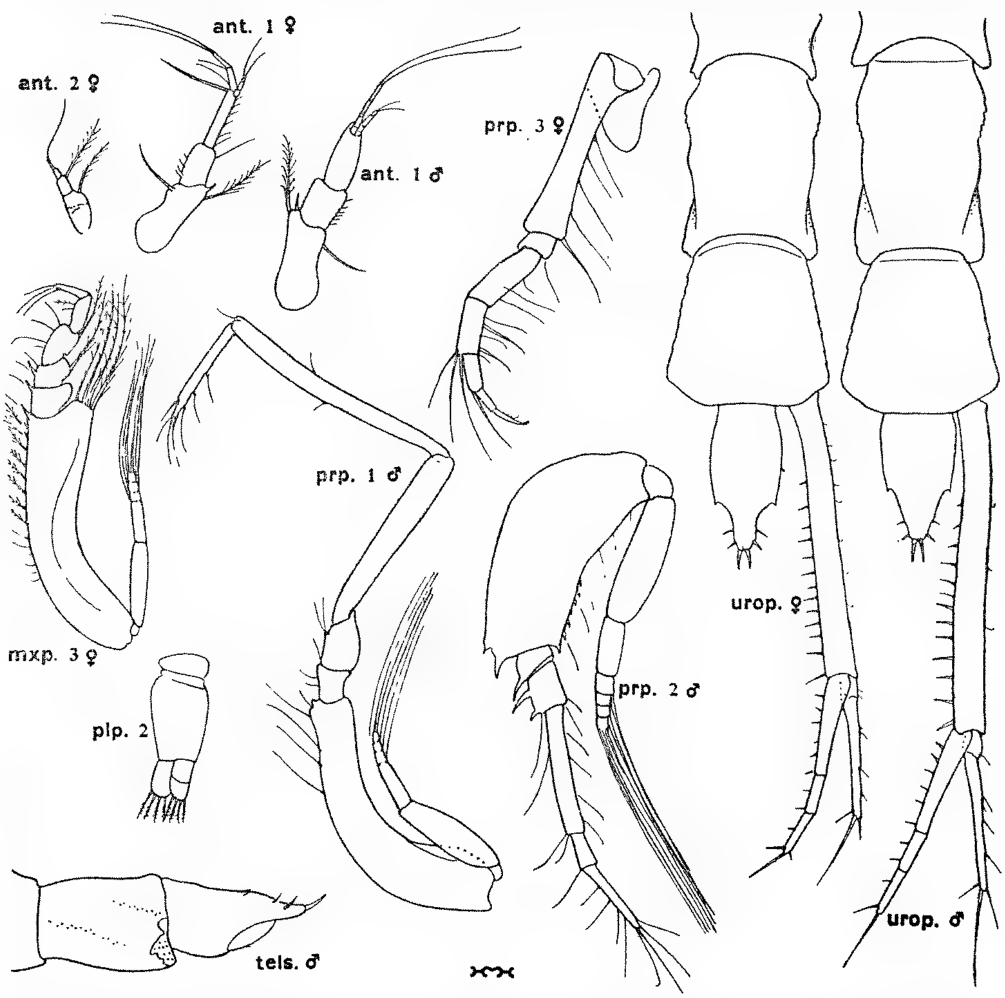

Fig. 11
Dimorphostylis inauspicata, paratypes male and subadult female; ant., first and second antennae; mxp. and prp., third maxilliped and first to third peraeopods; urop., uropod, telson and fifth to sixth pleon somites; tels., lateral view of telson (all x 37); plp. 2, second pleopod (x 70).

smaller tooth, at outer distal angle; it is not as long as rest of limb; ischium distinct, armed with a large outer tooth; merus with two teeth on outer margin; carpus three times as long as merus and nearly four times as long as propodus, which is not quite half as long as dactylus.

Basis broad in third and fourth peraeopods, and about as long as remainder of limb; merus nearly as long as carpus and propodus together; fifth peraeopod

with basis barely wider than, and not much more than half as long as, remainder of limb; three distal carpal setae, successively increasing in length, the longest (like the propodal seta) reaching to the level of tip of slender dactylus.

Peduncle of uropod two and three-fourths times as long as telson, three-fourths as long again as endopod, and with 13 spines on inner margin; endopod three-jointed, the first segment a little longer than second and third combined; second joint slightly shorter than third; inner spines of segments of endopod six plus two plus two, and terminal spine distinctly longer than last segment; exopod about as long as first two joints of endopod together, and with longest terminal spine more than half as long as ramus.

Both pairs of pleopods, though incompletely developed and with short setae, have the exopod two-jointed and the endopod not divided.

Colour, white. Length, 5·6 mm.

Female with developing marsupium—General form as in the young male illustrated.

First antenna differing from that of male in having the third joint narrow, the main flagellum consisting of two segments and the accessory of three short joints. Second antenna apparently four-jointed, the small terminal segment capped with a plain seta.

Armature and proportions of thoracic appendages as in the young male, excepting that the basis in the second to fourth peraeopods is much narrower. An exopod is present on the third maxilliped but is more slender than in the male. There are no exopods on the third and fourth legs.

Telson and uropods are as described but with peduncle of last-named only half as long again as endopod.

Length, 5·7 mm.

Loc.—New South Wales: Ulladulla, Brush Island, 45 fms., in fine silt on flathead grounds (D. Rochford, Jan. 1945). Types in S. Aust. Museum, Reg. No. C.2703.

The females available are not in good condition.

Dimorphostylis tasmanica sp. nov.

Female with developing marsupium—Integument thin but slightly calcified with surface dull.

Carapace plump and shaped as in *tribulis;* it is about one-third of total length of animal and twice as long as pedigerous somites together; antero-lateral fold armed with a row of strong teeth, posterior to which is a patch of smaller teeth, while there are scattered spines on anterior part of sides; mid-line of dorsum, posterior to ocular lobe with three conspicuous teeth, placed one behind the other, and at about middle of length with a couple of small spines; to the rear of antero-lateral fold the sides are shallowly pitted and bear exceedingly faint indications of three oblique furrows, not at all like the defined carinae of *tribulis;* branchial regions somewhat swollen and elevated on dorsum, where there is a deep median gutter between them; seen from the side the dorsal profile is irregular because of these elevations, the tumid ocular lobe, etc. Antero-lateral margin shallowly concave and antero-lateral angle with a tooth which is the first of a series running back along front portion of inferior margin (see fig. 12, c. pace). Pseudorostral lobes each with a small tooth at anterior end, meeting for a distance equal to one-sixth of length of carapace. Ocular lobe wider than long and with a pair of spines.

Pleon a little longer than cephalothorax, the sides of first to sixth somites with a few spines; the anterior five somites are indented on the sides, not smoothly

cylindrical; fifth somite one-fourth as long again as wide and not much longer than sixth, which is somewhat dilated posteriorly, where it is as broad as long; telson broadly subtriangular, two-thirds as long as sixth pleon somite, and with a pair of spines at the narrow apex; each side of telson, at about middle of length is produced as a tooth, immediately anterior to which is a bristle, and there are three pairs of lateral bristles, but no spines, in front of the terminal spines.

Third maxilliped with exopod about two-thirds as long as basis.

First peraeopod long, the carpus reaching a little beyond level of end of pseudorostrum; basis relatively short, much less than half as long as remainder of limb, with several teeth at distal end (including one at inner angle) and several

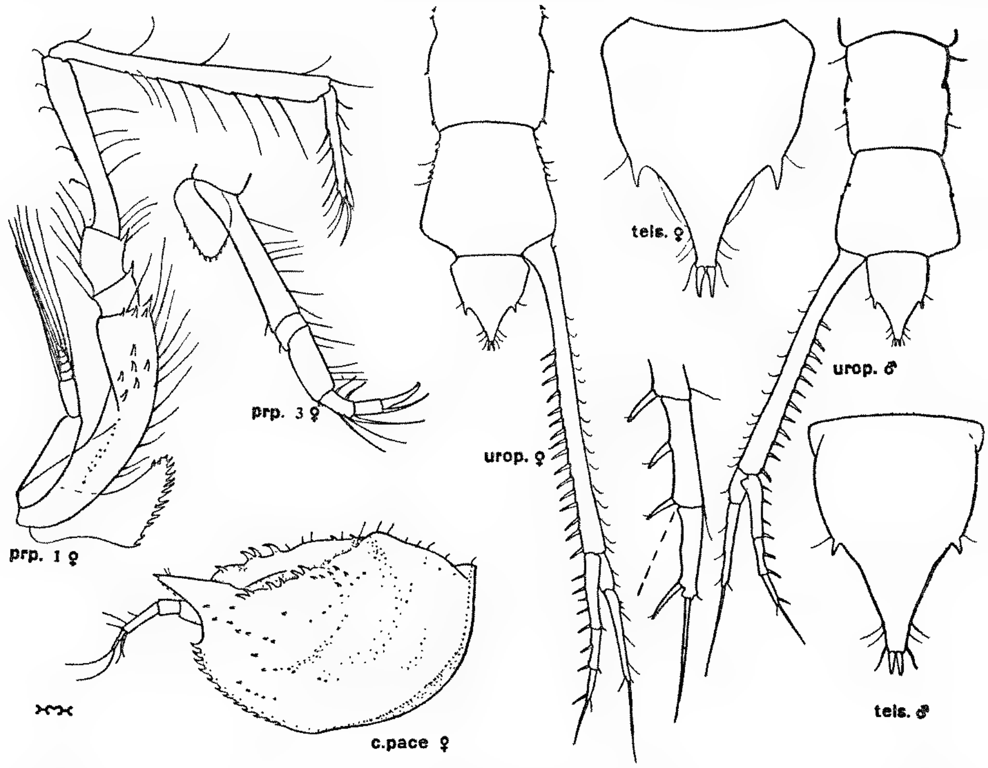

Fig. 12

Dimorphostylis tasmanica, type female and allotype male; c. pace, lateral view of carapace (x 21); prp., first and third peraeopods (x 32); urop., uropod with telson, etc. (x 32; distal joints of endopod, x 100); tels., telson (x 100).

on outer face; ischium and merus each with an inner apical tooth; propodus longer than combined lengths of ischium, merus and carpus, and two-and-one-half times as long as dactylus.

Second peraeopod without teeth on proximal joints; basis equal in length to remainder of limb and with a fringe of plumose setae on outer edge; ischium distinct; carpus twice as long as merus, nearly three times as long as propodus and a little longer than propodus and dactylus together; exopod longer than basis; edges of marsupial plate, like those of others, toothed.

Basis of third peraeopod about as long as rest of limb, that of fourth and fifth pairs relatively shorter; these posterior limbs are fairly stout; the merus is broader than in *inauspicata* and is longer than the carpus and propodus together; the propodal seta, like the longest of the three distal carpal setae, reaches to, but

not beyond, the tip of the stout dactylus, which is a little longer than either carpus or propodus; inner margin of carpus with two stout setae.

Uropod with peduncle distinctly longer than fifth and sixth pleon somites together and more than twice as long as endopod; its inner margin bears a row of sixteen spines in distal two-thirds of its length and its outer margin a row of fine, spaced setae; endopod with first joint little longer than second and third segments combined and with second nearly one-fourth as long again as third; inner spines of endopod four or five, plus two, plus one, and terminal spine about as long as second joint; exopod eight-ninths as long as endopod, with its slender terminal spine almost as long as its second joint.

Colour, creamy white. Length, 5·5 mm.

Subadult male—In general very like the female, and with similar armature, including the pair of spines on ocular lobe, the three median ones posterior to it, and the tooth at end of each pseudorostral lobe. A pair of small corneal lenses are discernible on ocular lobe. First legs as in female, with very long propodus.

The telson is relatively a little longer than in female but has the same lateral teeth, bristles and terminal spines (*cf.* tels. ♂ ♀, fig. 12).

Finally, the uropods are much as in the female, except that the peduncle is a little shorter in relation to the rami and has only 12 to 13 spines on inner edge, features which may be attributed to immaturity.

Length, 4·6 mm.

Loc.—Tasmania: off Babel Island, latitude 39° 55′ S., longitude 148° 31′ E. ("Warreen" Station 29, Jan. 1939). Types in S. Aust. Museum, Reg. No. C.2728.

Dimorphostylis vieta (Hale)

Pachystylis vieta Hale, 1936a, 424, fig. 14-15, and 1937, 72.

The species is available from St. Vincent and Spencer Gulfs, South Australia. The previously unknown adult male, described below, has the basis of the first to fourth peraeopods expanded, and in general agrees so closely with males of the other Australian species referred to *Dimorphostylis* that it can scarcely be separated generically. In one respect, however, the males show some discrepancy in that the pleopods are rather more rudimentary than is usual in the genus.

Most of the species placed in *Dimorphostylis* have oblique lateral ridges posterior to the level of hinder end of frontal lobe. In the female of *vieta* these are characteristically represented by series of low elevations, sometimes capped with setae. The curved antero-lateral fold (present in all species) is sometimes armed with a few spines, never so numerous as in *tribulis* and *tasmanica*. In the two last-named and in *inauspicata*, the distal carpal and propodal setae of the fossorial legs do not reach beyond the tip of the dactylus, as they do in the other Australian species excepting *D. vieta* which has these setae even shorter, and not reaching to end of dactylus.

The broad carapace and the proportions of second peraeopod and uropod provide other good distinguishing features for the species.

Adult male—Integument transparent, scarcely at all calcified, granulate on dorsal and dorso-lateral parts of carapace.

Carapace less than two-fifths of total length, nearly twice as long as deep, and about one-fourth as wide again as deep; there are three ill-defined longitudinal folds on each side (see fig. 13) and a pair of faint, irregular, longitudinal ridges on back, margining a slightly concave median area. Antero-lateral margin oblique, scarcely concave, and antero-lateral angle rounded, with two denticles.

Pseudorostrum subacute anteriorly, both as seen from above and from side, rather wide basally and with the lobes meeting for a distance equal to fully one-sixth of total length of carapace. Ocular lobe large, twice as wide as long and with three prominent, tumid, pale lenses, with granular structure.

Pedigerous somites together only half as long as carapace; pleural parts not much expanded in any, but those of first concealed by second.

Pleon not much shorter than cephalothorax; fifth somite little longer than sixth, which is somewhat widened posteriorly, where it is almost as broad as long; telson larger than in female, three-fourths as long as sixth pleon somite, subcylindrical for greater part of length then tapering suddenly to the narrow apex; there is an extremely short post-anal part, with a pair of short terminal spines

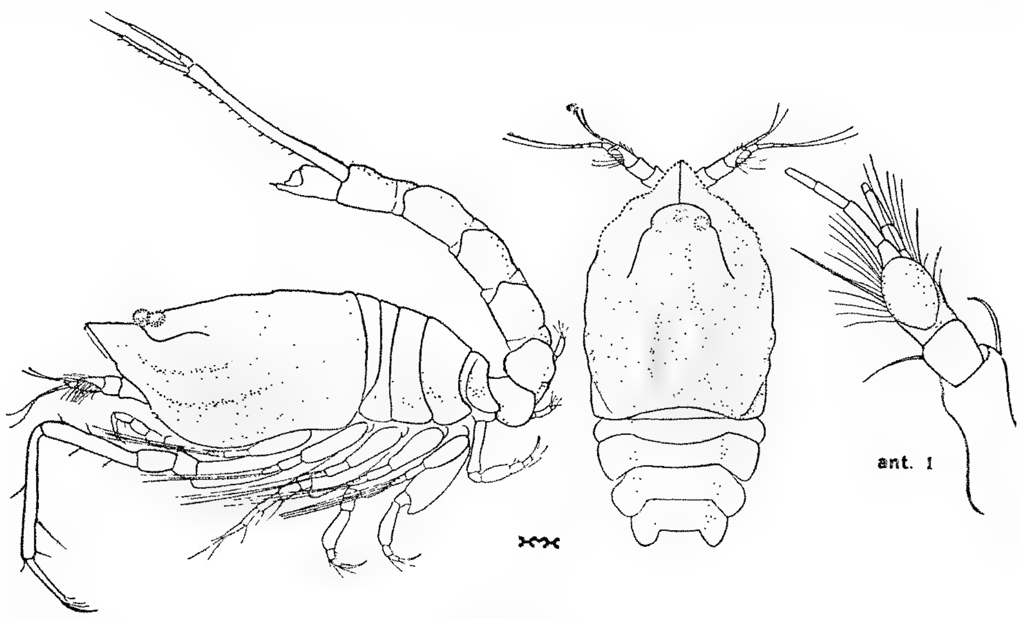

Fig. 13

Dimorphostylis victa, adult male; lateral view and cephalothorax from above (x 30); ant. 1, ventral aspect of first antenna, the terminal appendages of flagella omitted (x 80).

flanked by a bristle on each side (these spines are sometimes longer in the female than is shown for the type, but are always small).

First antenna with basal segment not quite as long as second and third joints together; the third peduncular joint is half as long again as second and bears a stout seta, and a rather dense fringe of hairs around an oval ventral area; flagellum four-jointed, as long as the two distal segments of peduncle combined; accessory lash four-jointed (the last segment tiny) and relatively long, being equal in length to last peduncular joint.

Second antenna with flagellum long, reaching to end of pleon and with very elongate joints; it is furnished with minute spinules but no dense fringe of hairs.

Mandible with 10 or 11 spines in the row.

Third maxilliped with basis half as long again as rest of limb, its external angle not forwardly produced and with the usual fringe of stout and long plumose setae.

First peraeopod stout and long, the merus reaching beyond level of antennal angle, and carpus beyond that of pseudorostrum; basis half as long as rest of limb

with two of the plumose setae distal and long; propodus a little longer than carpus, twice as long as ischium and merus together, and more than twice as long as dactylus, the terminal seta of which is stout and claw-like.

Basis of second peraeopod (like that of third and fourth) produced distally; it is half as long again as remainder of limb; ischium distinct; carpus a little longer than either merus or propodus and subequal in length to dactylus.

Remaining peraeopods rather robust, with basis longer than rest of limb in third and fourth, shorter in fifth; merus of third and fourth not much shorter than carpus, propodus and dactylus together; longest distal carpal seta not nearly attaining, and propodal seta reaching, level of tip of dactylus.

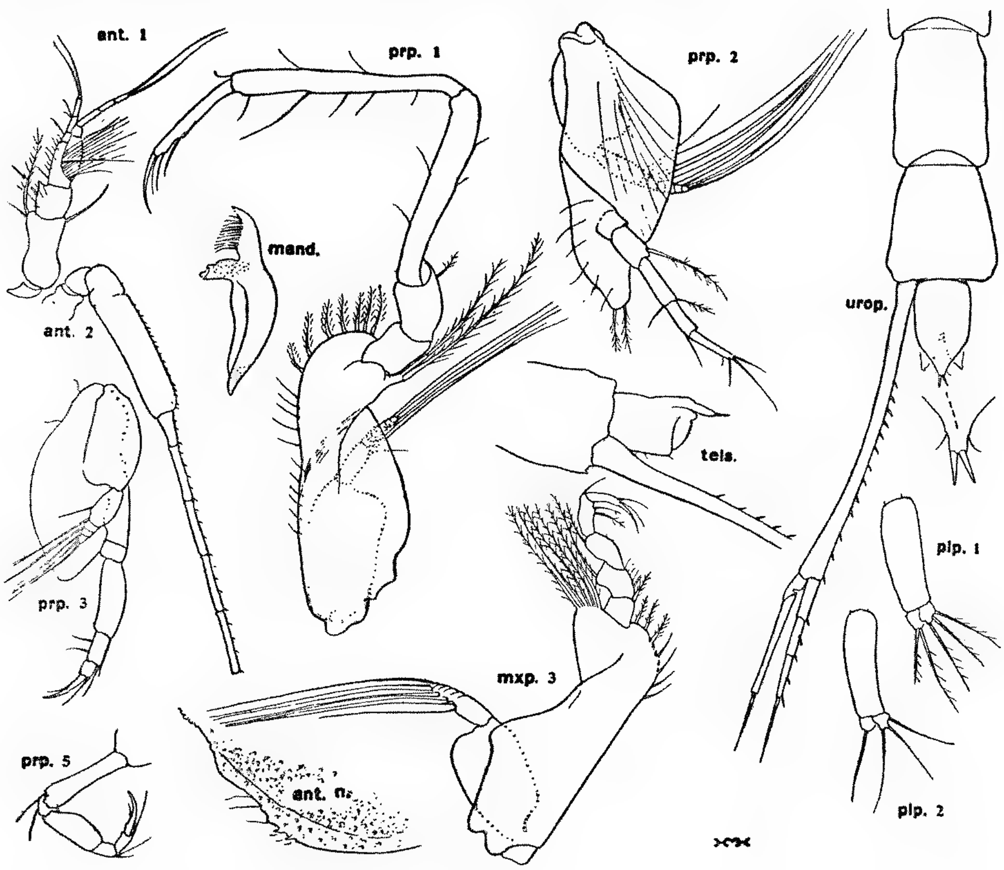

Fig. 14

Dimorphostylis vieta, adult male; ant. n., antero-lateral margin and angle; ant. 1, first antenna and upper lip; ant. 2, second antenna, only the proximal joints of flagellum shown; mand., mandible; mxp. and prp., third maxilliped and peraeopods; urop., uropod with fifth to sixth pleon somites and telson; tels., lateral view of telson (all x 50); plp., pleopods (x 120).

Each of the two pairs of pleopods are biramous, both rami single-jointed; the setae are sparse (see fig. 14, plp. 1-2).

Peduncle of uropod very long and slender, almost equal in length to fifth and sixth pleon somites and telson combined; the distal three-fourths of the inner edge bears a row of a dozen or so short spines; exopod and endopod subequal in length, each with a terminal spine about half as long as the rami; endopod divided into three segments, the first and third subequal in length, the second a little shorter; inner margin with one, two and two spines respectively.

Length, 3·3 mm.

Secured in Spencer and St. Vincent Gulfs, South Australia, at night, by townet or submarine light.

Zimmer (1921, 148) considers that *Dimorphostylis* may be closely related to *Pachystylis* (Hansen, 1895, 58). The recent examination of a score of species referable to *Gynodiastylis* leaves one with the impression that the affinities of *Pachystylis rotundata* lie more with that genus (see also Zimmer, 1914, 192) than with *Dimorphostylis.* Fuller information regarding Hansen's Brazilian species must be awaited.

Dimorphostylis colefaxi sp. nov.

Female with developing marsupium—Integument lightly calcified, tough but not brittle.

Carapace less than one-third of total length of animal and not much longer than pedigerous somites together; it is more than half as long again as deep and is as wide as deep; seen from above the sides are subparallel in proximal half; on

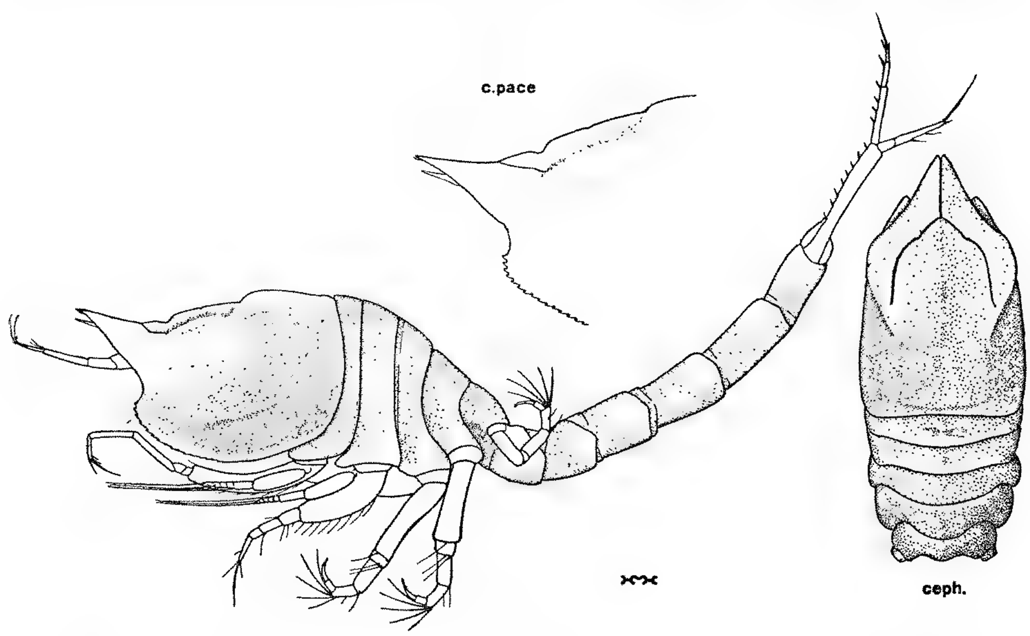

Fig. 15
Dimorphostylis colefaxi, type female; lateral view and (ceph.) cephalothorax from above (x 24); c, pace, anterior portion of carapace (x 36).

each side a dorso-lateral fold curves back from pseudorostrum around frontal lobe to beyond middle of length; as in other Cumacea with similar sculpture these elevations are most conspicuous when the animal is viewed from above; the dorsal space between the folds is somewhat flattened, but rises to a low ridge medianly; in posterior third of length of carapace the dorsum is slightly excavate and on each side this hollow is emphasised by a low fold; below dorso-lateral ridge there is on each side a shallow concavity beneath which, and subparallel to inferior margin, is a faint, curved carina, above which the surface is faintly pitted, resulting in an obscurely reticulated appearance; seen from the side the pseudorostrum is acutely pointed in front and the dorsal contour is irregular because of the folds alongside the dorsal concavity and a couple of slight incisions in the median ridge of anterior half (fig. 15, c. pace).

Pedigerous somites not differing much in length; with pleural parts expanded but not conspicuously so; second and third legs separated by a wider interspace than third and fourth, but even so by no means well separated.

Pleon shorter than cephalothorax, the somites successively increasing in length to fifth; sixth less than two-thirds as long as fifth, dilated posteriorly, where it is distinctly wider than long; telson cordate, less than three-fourths as long as sixth somite, with a very abbreviated post-anal portion and a pair of slender terminal spines flanked on each side by a bristle.

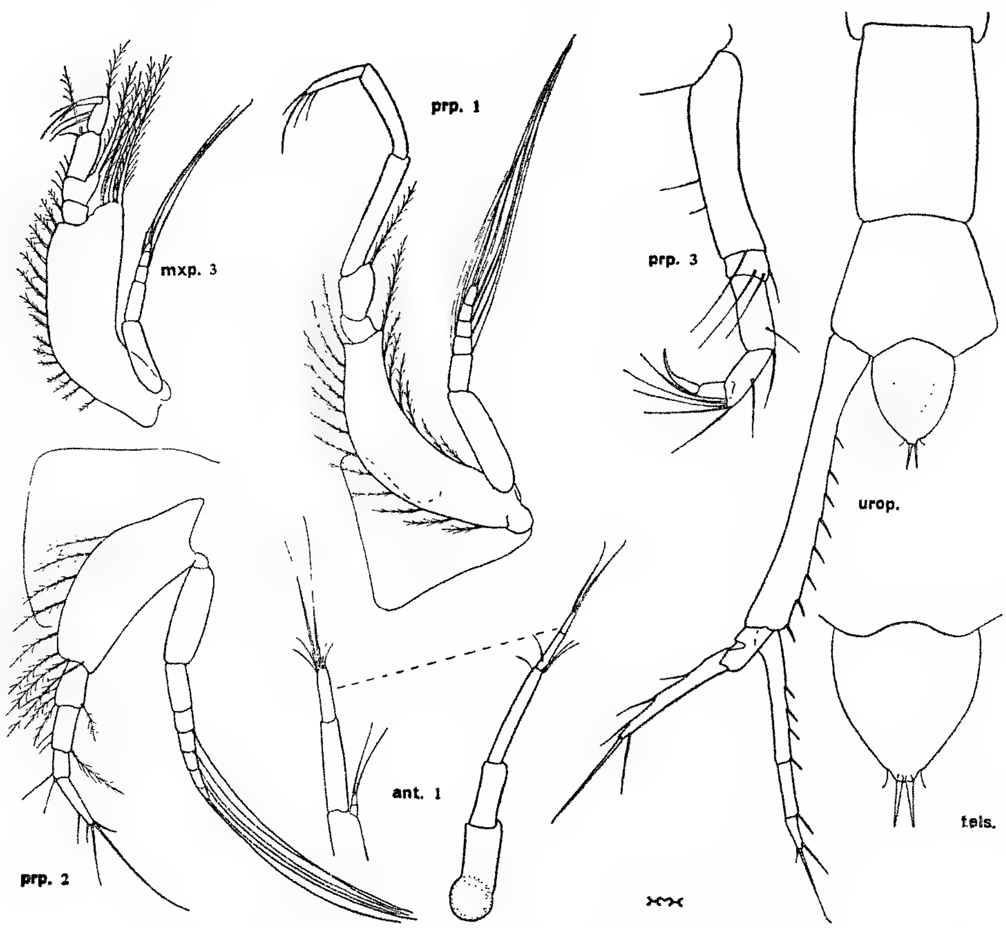

Fig. 16

Dimorphostylis colefaxi, type female; ant., first antenna (x 56; flagella, x 126); mxp. and prp., third maxilliped and peraeopods (x 56); urop., ventral view of uropod, fifth to sixth pleon somites and telson (x 56); tels., dorsal view of telson (x 85).

First antenna slender and rather long; third joint of peduncle fully as long as first, and half as long again as second; flagellum stout, composed of two joints, the first of which is two-thirds as long again as second; accessory flagellum insignificant, two-jointed.

The second antenna has the plumose setae thickly clogged with sediment and the joints cannot be made out.

Third maxilliped with exopod well developed; basis large, one-third as long again as rest of limb and with outer apical part a little produced forwards; carpus

longer than any other of the remaining joints and almost twice as long as the rather small dactylus.

First peraeopod small, reaching when extended barely beyond level of front of pseudorostrum and with the carpus reaching antennal angle; basis shorter than rest of limb, with plumose setae on both margins; carpus more than twice as long as merus (which bears an outer distal plumose seta) and one-third as long again as propodus, which is more than half as long again as dactylus.

Second peraeopod with the stout basis shorter than the exopod but considerably longer than rest of limb; ischium suppressed; merus and carpus subequal in length, each half as long again as propodus, which is not much more than half length of dactylus; one of the terminal dactylar setae is slender, and is as long as the three distal joints together.

Third and fourth peraeopods stout, the basis little shorter than remaining joints together; carpus almost as long as merus, and with four distal setae, the longest, like propodal seta, reaching well beyond tip of dactylus.

Peduncle of uropod narrow, almost as long as fifth and sixth pleon somites together and armed on inner margin with a row of nine spaced spines; endopod one-fourth as long again as exopod and a little less than three-fourths as long as peduncle; it is three-jointed, with the first joint two-and-one-half times as long as second, which is two-thirds as long again as the distal joint; inner spines four, one and one, and longer terminal spine less than half as long as the ramus; exopod with three setae on outer margin and one (subdistal) on inner; distal spine more than half as long as the ramus.

Colour, creamy-yellow. Length, 4·2 mm.

Loc.—New South Wales: Lake Illawarra (A. N. Colefax, June 1937) Type in S. Aust. Museum, Reg. No. C.2683.

It should be noted that Lake Illawarra, like the Noosa River in Queensland, is an inlet of the sea. The species is named after its collector, Mr. A. N. Colefax, Lecturer in Zoology of the University of Sydney.

Dimorphostylis cottoni Hale

Dimorphostylis cottoni Hale, 1936, 400, fig. 5-6 (male only).

Material now referred to this species is available from more than a score of localities off South Australia, Tasmania and New South Wales (long. 136° to 152°; lat. 32° to 40°). Adult males far outnumber ovigerous females in the hundreds of specimens taken by submarine light, Agassiz trawl, and townet.

The carinae of the carapace of some New South Wales examples are much more distinct than in material from South Australia, and also appear to be more markedly crenulate. These ridges are also somewhat variable in disposition; the one immediately behind the frontal lobe may run completely across the back and in some specimens, both male and female, and from both South Australia and New South Wales, there is an additional lateral ridge towards the rear of the carapace (x in fig. 17, ceph.).

The size is variable, both adult males and ovigerous females, ranging from barely more than 4 mm. to over 7 mm. in length. The telson of the female has usually two pairs of lateral spines, but sometimes three are present on one or both sides, and occasionally only one pair is developed. In the male the position is different. Young examples and small adults (5 mm. or so in length) have the telsonic spines as in the female, but in the larger mature males (6 mm. to 7 mm.) lateral spines are completely absent. The average size of adults taken in sheltered waters (such as in the closed bay of Port Lincoln in South Australia) is smaller

than that of those from more open seas, and it is amongst the latter, from both southern and eastern coasts, that the males without lateral telsonic spines are found; in these last the flagellum of the second antenna reaches to the end of the rami of the uropods.

The U-shaped ridge enclosing the depression in the dorsum of the male telson is well developed, and is just as in *Paradiastylis longipes* (Calman, 1905, 21, fig. 4). The armature of the uropods of the adults of this sex is variable, the spines being usually a trifle more numerous in the aforementioned large males than they are in the type and in examples of similar size to this. The peduncle has on inner edge 12 to 18 spines, the joints of the endopod 12 to 16, plus one to three, plus one or two. The pleopods have the exopods two-jointed, the second segment very short (fig. 18, plp.).

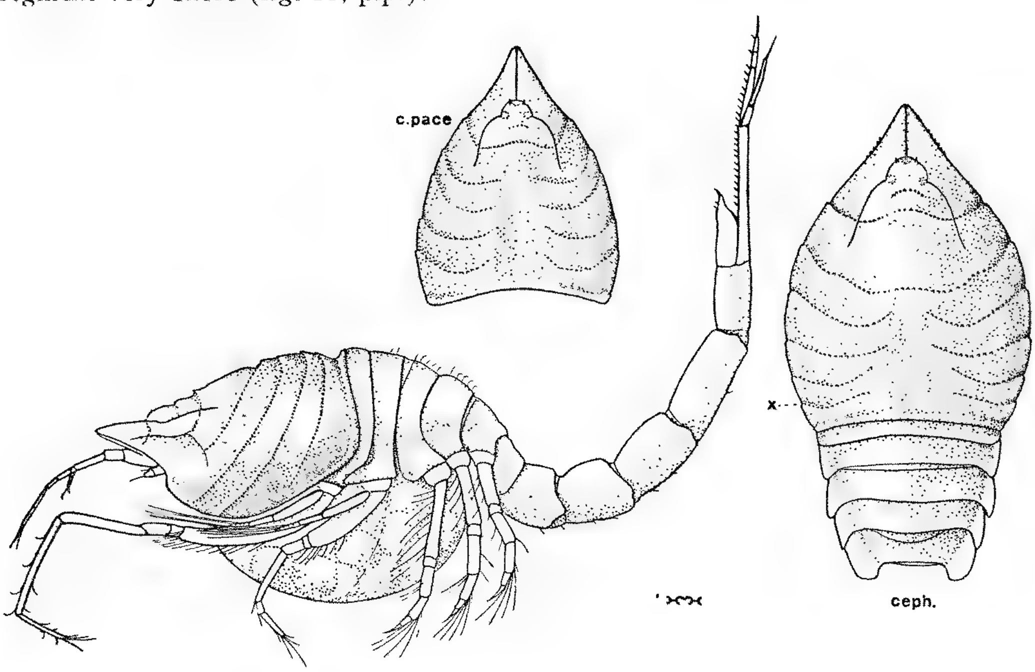

Fig. 17

Dimorphostylis cottoni; lateral view of 4·2 mm. ovigerous female and (c. pace) carapace from above; ceph., cephalothorax of subadult 5 mm. female (all x 25).

The type is described as having a single corneal lens on the ocular lobe; examination of further material shows that three lenses are present in both sexes, but in most preserved specimens they are extremely difficult to see. Material in alcohol is semi-transparent, but Mr. Sheard notes that some examples he collected in South Australia in 1941 were bright orange in colour during life. Some specimens recently found amongst plankton collected in St. Vincent Gulf by the writer, and preserved for a few hours in formalin, and then for a short time in alcohol, had red eyes, a few red spots on the sides of third and fourth pedigerous somites and a red spot on each side of the fifth pleon somite; the general body colour was yellow.

Ovigerous female—Integument membranous. Carapace a little less than one-third of total length of animal, nearly half as long again as pedigerous somites together, distinctly wider than deep and three-fourths as long again as deep. Antero-lateral margin scarcely concave, antero-lateral angle rounded, and inferior margin very finely serrate. Pseudorostrum narrow, subacute in front when viewed from above or from the side, the lobes meeting for a distance equal to

from one-fifth to one-sixth of length of carapace. Ocular lobe much wider than long, armed with a pair of denticles in front.

Pedigerous somites not much expanded on sides; fourth and fifth a little longer than the others.

Pleon, as in male, distinctly longer than cephalothorax; fifth somite subcylindrical, twice as long as wide and one-third as long again as sixth, which is not very greatly dilated posteriorly, where it is about four-fifths as wide as long; telson not quite as long as sixth somite.

First antenna without the brush of sensory setae present in the male; first joint of peduncle nearly twice as long as second and about equal in length to the

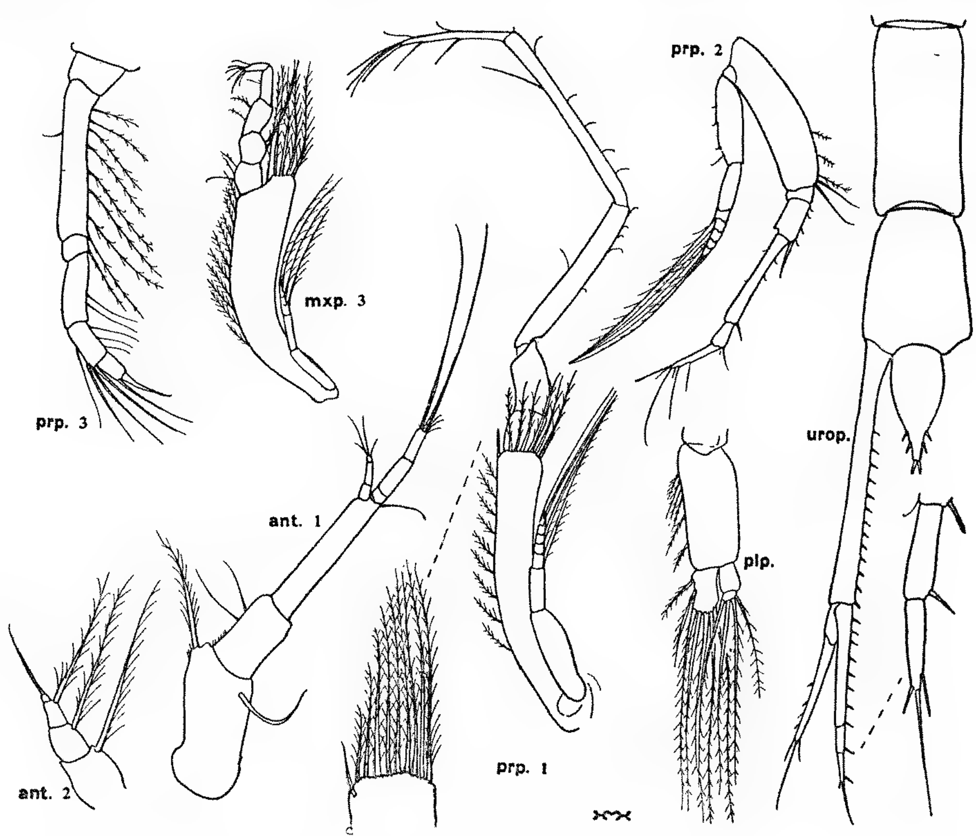

Fig. 18

Dimorphostylis cottoni, ovigerous female; ant., first and second antennae (x 86); mxp. and prp., third maxillipeds and peraeopods (x 43; distal end of basis of first peraeopod, x 86); urop., uropod with fifth to sixth pleon somites and telson (x 43; distal joints of endopod, x 172). plp., Pleopod of male (x 86).

slender third segment; flagellum as long as second peduncular segment and composed of three joints, the first short, the other two subequal in length; accessory lash three-jointed, about half as long as main flagellum, and with distal segment small. Second antenna with first joint longer than second, which is longer than third, and with fourth and last very small; first three segments each with a plumose seta, terminal one capped with a plain seta.

Branchial lobes digitiform and, as in male, about seven in number, the posterior ones small.

Third maxilliped with exopod only about half as long as basis, which is half as long again as combined lengths of remaining joints, which do not differ much in length save that the dactylus is distinctly shorter than propodus.

First peraeopod with carpus reaching well beyond level of anterior end of pseudorostrum; basis half as long as remainder of limb, its distal end with a series of graded plumose setae; propodus only about one-fifth as long again as carpus and twice as long as dactylus.

Second peraeopod less than half as long as first; basis two-thirds as long as rest of limb; ischium distinct; carpus more than twice as long as merus, four times as long as propodus, and not quite twice as long as dactylus.

Second and third peraeopods separated more widely than any of the others. Third to fifth with basis distinctly shorter than rest of limb, with merus as long as carpus and propodus together, and with dactylus long and slender; the distal carpal setae, like the propodal seta, reach well beyond end of dactylus.

Peduncle of uropod more than twice as long as telson and half as long again as endopod, which is one fourth as long again as exopod; it has about a dozen spines on inner margin, first segment of endopod fully twice as long as combined lengths of the subequal second and third joints; spines of inner margins of endopod joints usually about ten plus one plus one.

Fig. 17 gives the lateral view and carapace of a female 4·2 mm. in length (Port Lincoln, South Australia), and the cephalothorax of a larger subadult female from New South Wales. The largest ovigerous female is 7·1 mm. in length, and its ova are 0·23 mm. in diameter.

Dimorphostylis tribulis sp. nov.

Ovigerous female—Integument thin but considerably calcified; surface, except for carinae and spines as described, almost smooth, dull and not at all polished. Sparsely clothed with short plumose hairs which tend to collect algal debris, forming a coating concealing the surface sculpture.

Carapace plump, wider than deep and little more than half as long again as deep; it is almost twice as long as pedigerous somites together, and less than one-third of total length of animal; seen both from above and from the side it is sub-oval and tapering towards the front in anterior fourth of length; the antero-lateral fold is armed with an irregular row of spines and the dorsum on and behind frontal lobe bears a few spines, one more prominent than the others; posterior to frontal lobe each side has three curved carinae, the first of which is spinose and is joined near lower edge of carapace by the second, the short connecting part also spinose. Antero-lateral margin quite deeply concave for the genus; inferior margin strongly serrate, the most anterior of the teeth emphasising the antero-lateral angle; pseudorostral lobes meeting for a distance equal to one-sixth of length of carapace; each terminates dorsally in a small tooth, and seen from the side has the anterior end narrowly subtruncate. Ocular lobe wider than long, denticulate.

Pedigerous somites successively increasing in dorsal length to fourth, and fifth a little longer than third; third somite expanded fore and aft, but second and third peraeopods no more widely separated than the others.

Pleon stout, longer than cephalothorax, with a few scattered spines on sides, which in the first to fifth somites are uneven, not smoothly cylindrical; fifth somite not conspicuously longer than sixth, which is scarcely dilated posteriorly, where it is as wide as long; telson shorter than sixth somite, subtriangular, with sides entire but sinuate; post-anal part short, armed with a single terminal spine and two pairs of lateral spines, anterior to which are two widely spaced pairs of setae.

Mandible with 12 to 13 spines.

First joint of peduncle of first antenna stout, one-third as long again as third, and two-and-one-half times as long as second; it is armed with a small distal tooth and has the usual large plain seta and distal plumose seta; flagellum half as long as first peduncular segment, three-jointed, the first joint the longest and the second shorter than third; accessory lash half as long as main flagellum and three-jointed, the proximal and distal segments short. Second antenna with terminal joint very small and capped with a plain seta; first to third segments with the usual plumose setae.

Third maxilliped as in *inauspicata,* with exopod about three-fourths as long as basis.

First peraeopod long, the carpus reaching to level of apex of pseudorostrum; basis short, much less than half as long as remaining joints together, with a small

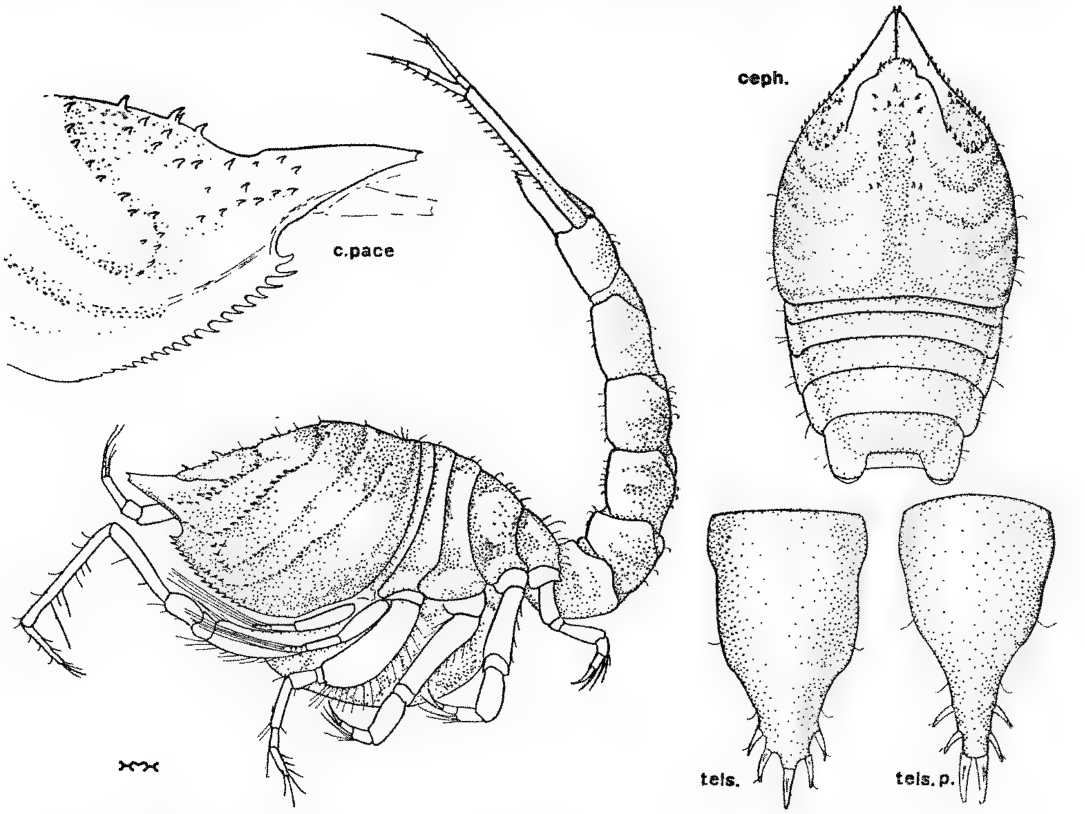

Fig 19

Dimorphostylis tribulis, type female; lateral view and (ceph.) cephalothorax from above (x 22); c. pace, anterior part of carapace, with frontal lobe removed (x 44); tels., telson (x 88); tels. p., telson of paratype ovigerous female (x 88).

tooth at inner distal angle and a dense distal brush of plumose setae; ischium with a tooth at inner apical angle; propodus equal to combined lengths of merus and carpus, twice as long as propodus and little shorter than basis.

Second peraeopod with basis unarmed but with fine and dense plumose setae on inner margin; it is not quite as long as remaining joints together; ischium distinct; carpus elongate, almost twice as long as merus, and two-and-one-half times as long as propodus, which is two-thirds as long as dactylus; setae of last-named slender, the longest terminal ones much exceeding the joint in length.

Third to fifth peraeopods robust; basis not quite as long as rest of limb in third pair, relatively shorter in the others; merus a little longer than carpus and propodus together; propodal seta and longest of the three distal carpal setae not reaching beyond tip of the stout claw-like dactylus; on its inner margin the carpus has two stout setae, which are longer in fourth and fifth peraeopods than they are in the third pair.

Peduncle of uropod not quite as long as fifth and sixth pleon somites and telson together, twice as long as endopod and with 14 spines on inner margin; endopod with first joint nearly one-third as long again as second and third segments together; second more than one-third as long again as third; spines on inner margin number four plus two plus one, and the slender terminal spine is

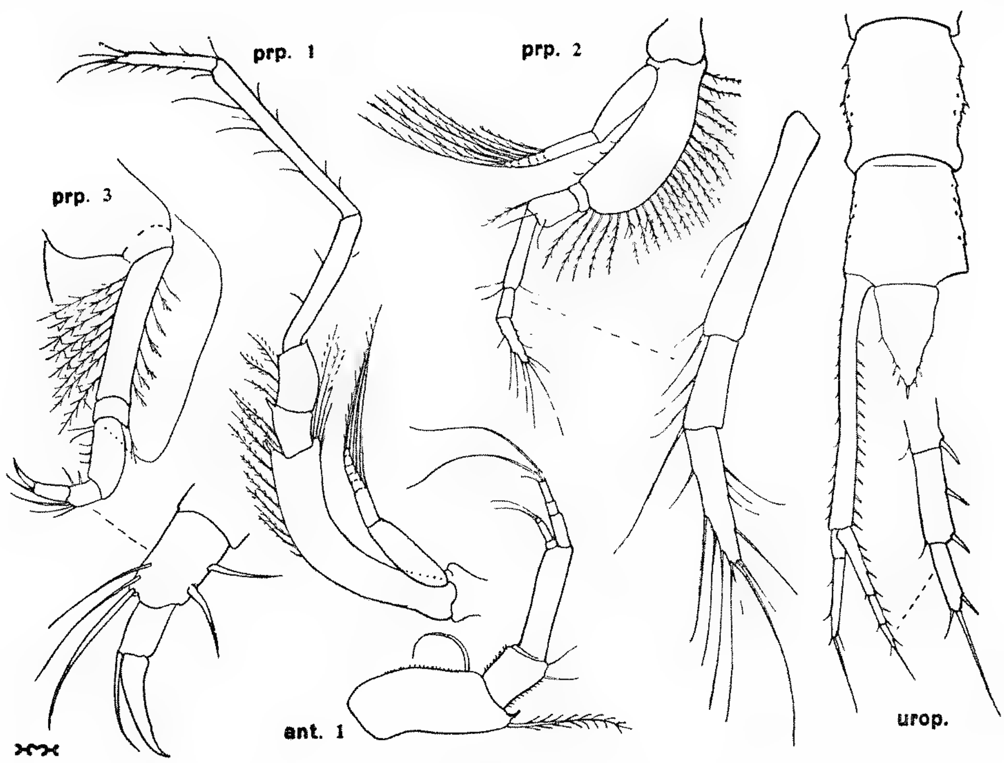

Fig. 20
Dimorphostylis tribulis, type ovigerous female; ant., first antenna (x 70); prp., first to third peraeopods (x 38; distal joints, x 100); urop., uropod with fifth to sixth pleon somites and telson (x 38; distal joints of endopod, x 100).

longer than second joint; exopod a little longer than first two segments of endopod together, with terminal spine as long as its second joint.

Colour, creamy-white. Length, 5 mm.

Loc.—South Australia: Kangaroo Island, Antechamber Bay, dredged in daylight, 7 fms. and submarine light, surface at night with tide running strongly (K. Sheard, April 1941). Type ovigerous female in S. Aust. Museum, Reg. No. C.2800.

The telson of the type female is not perfectly symmetrical and should be regarded as abnormal in regards to terminal armature; the usual condition is as in the telson of the ovigerous female shown in fig. 19, tels. p.

This species is easily separated from the other two occurring in South Australia. The conspicuously stouter third to fifth peraeopods and the lesser number

of lateral carinae of the carapace at once distinguish it from *cottoni*, and it may be added that the last-named characteristically has a clean integument but *tribulis*, at least in the case of the ovigerous female, is coated with flocculent material. In some respects *tribulis* resembles *vieta* more closely, particularly when the latter has a few spines on the antero-lateral fold; apart from size there are, however, many small points of difference. The character most readily checked is found in the endopod of the uropod of *vieta*, where the three segments do not differ much in length, a feature not found in any other species of the genus.

D. tribulis is close to *tasmanica*, which, however, has (1) no well-marked carinae on sides of carapace posterior to the antero-lateral fold; (2) a small tooth on each side margin of the telson, which lacks articulated lateral spines in both sexes; (3) the first peraeopod longer and of different proportions.

Genus **Anchistylis** nov.

Generally resembling *Colurostylis* (Calman, 1911, 376) but with the pleopods of the male much modified. In each of the two pairs there is only one unjointed ramus. The ramus of the first bears a pair of strong hook-like setae, that of the second three non-plumose setae of different type. The endopod of the uropod is three-jointed in both sexes. The second antenna of the female is four-jointed, the last segment tiny, the penultimate large. That of the male has the flagellum composed of very long, slender joints, and reaching to or beyond end of pleon.

The basis in the first to fourth peraeopods of the male is expanded as in *Paradiastylis* and *Dimorphostylis*, but less markedly; it is produced well beyond the articulation of the ischium.

Genotype *Anchicolurus waitei* Hale.

Zimmer (1930, 651) places *A. waitei* in *Colurostylis*, evidently not regarding Stebbing's *Anchicolurus* as separable from Calman's genus. In view of the variation which occurs in *Gynodiastylis*, the number of joints of the endopod is not alone very important and the relative lengths of propodus and dactylus of the second leg can scarcely be regarded as of generic value. Calman, however (1912, 670-674) mentions other noteworthy characters wherein his Californian *Colurostylis* (?) *occidentalis* (later the type of *Anchicolurus*—Stebbing, 1912, 176, and 1913, 130) does not conform with the two New Zealand species which he admits, *viz.*, the genotype, *pseudocuma*, and *lemurum* (Calman, 1911, 376, pl. xxxvi, fig. 23-26, and 1917, 153, fig. 7-8).

A. waitei agrees with Calman's genus in the form of the telson; this is rounded, subcordate and without armature or postanal portion in the female, but in the male with a distinct post-anal part bearing a pair of very slender spines, or bristles, set a little below the actual tip (see fig. 21, tels.). There is also marked sexual difference in armature in *Allodiastylis* (Hale 1936a, 72), etc.

Calman refers to the very small size of the telson of his forms; the relative length of this somite varies greatly in the three species here referred to *Anchistylis* and, indeed, exhibits some variation within the limits of one species.

The integument is semi-transparent with little or no calcification.

Key to Species of Anchistylis

1 Second joint of endopod of uropod at least half as long again as third. *waitei* (Hale)
Second joint of endopod of uropod not longer than third. 2

2 Adult female. Telson small, one-half as long as sixth pleon somite or less. First peraeopod with basis as long as remaining joints together. .... *similis* sp. nov.
Adult female. Telson large, more than three-fourths as long as sixth pleon somite. First peraeopod with basis much shorter than remaining joints together. *longipes* sp. nov.

ANCHISTYLIS WAITEI (Hale)

Anchicolurus waitei Hale, 1928, 45, fig. 15-16, and 1936, 418.
Colurostylis waitei Zimmer, 1930, 651.

A good number of specimens are now available from the southern coasts of Australia.

The posterior margin of the antero-lateral depression of the carapace is finely serrate, as is also the curved dorso-lateral ridge; the antero-lateral angle is produced as an acute tooth in both sexes and the margin behind it is feebly serrate.

The telson varies in length. In the female type, taken on the south-eastern coast of South Australia, it is about two-thirds as long as the peduncle of the uropod, but in females from St. Vincent and Spencer Gulfs and from Victoria it is shorter, only half as long as the peduncle (bottom right in fig. 24). Spines at distal end of male telson about one-third as long as telson.

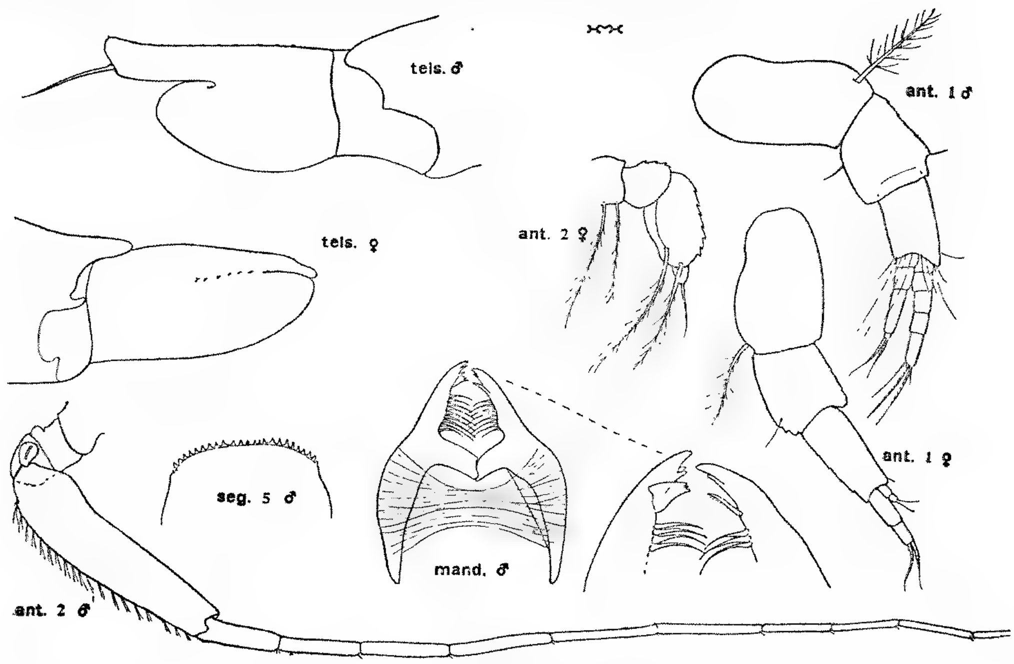

Fig. 21

Anchistylis waitei, ovigerous female and adult male; ant. 1 ♂ and ant. 1–2 ♀, first and second antennae (x 120); ant 2 ♂, second antenna (x 55, only proximal part of flagellum shown); mand., mandibles (x 55, distal portions, x 120); tels., lateral views of telson (x 120); seg. 5, anterior edge of fifth pedigerous somite (x 55).

Mandible with eight to nine spines in the row.

The external distal angle of basis of third maxilliped is forwardly produced, reaching just beyond level of distal margin of ischium in the female, and much beyond this in the male; in the female the basis of this appendage is almost twice as long as the remaining joints together, and fully half as long again as exopod.

Basis of second peraeopod less than two-thirds as long as rest of limb in adult female.

Uropod with peduncle subequal in length to rami in female, a little longer in male; second joint of endopod about half as long again as third in both sexes.

The pair of strong, hook-like setae on the ramus of the first pleopods are about as long as the peduncle and curve outwards and forwards; their tips bear

a few tiny plumes; no other large setae are present on this appendage, but there is a pair of plumose setae near their base.

Ramus of second pleopod with three unequal composite setae; one of these, seated at distal end, is stout and apically bifid, one on anterior edge (lower edge when the pleopod lies along venter of somite in normal position) is long and more slender, while another, also moderately stout, is situate on the upper or posterior edge. At the base of ramus the outer distal angle of peduncle bears a bifid seta like that of apex of ramus.

The function of these curious pleopods is apparent in some of the many males preserved in alcohol. When in a resting position the long lash of the second antenna lies beneath the sides of the carapace and pleural parts of the first four pedigerous somites, then against the underside of the pleon, in much the same way as in some other Diastylids where this appendage is long. It emerges at the rear of the fourth pedigerous somite, thence passes outside the basis of the fifth peraeopod, and beneath three stout plumose setae on the prominent postero-lateral rounded portions of the fifth pedigerous somite (fig. 22). It is then held down by the hooks of the first pleopod, the tension producing a sharp bend, at an

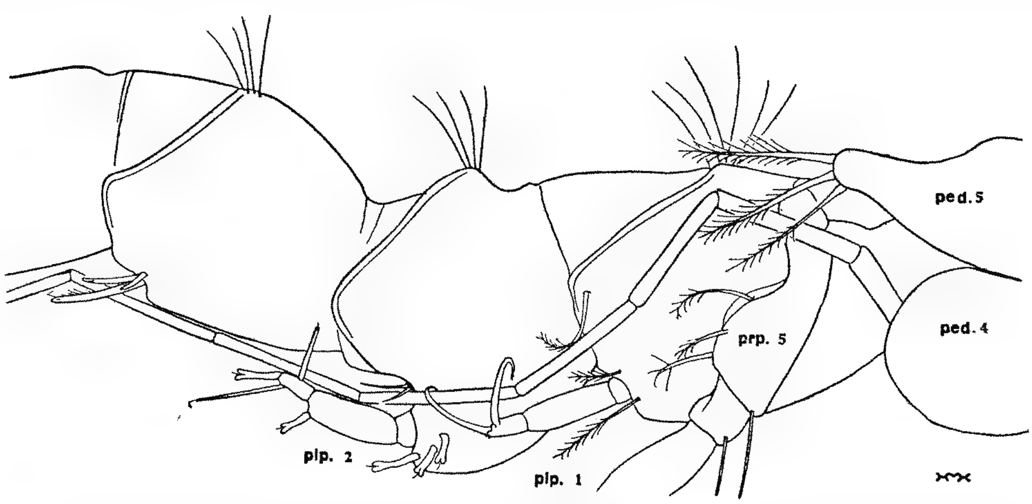

Fig. 22

Anchistylis waitei; first three pleon somites, etc., showing the anchoring of flagellum of second antenna by pleopods (x 120). ped 4-5, Posterior parts of fourth and fifth pedigerous somites; prp. 5, fifth peraeopod; plp. 1 and 2, pleopods.

articulation, immediately behind the thorax, and another less pronounced at the end of the joint actually caught by the hooks; this joint, incidentally, may be very slightly curved by the tension.

The second pleon somite is much produced ventrally, particularly posteriorly; seen from below the protuberance is cordate and tapers to the rear, where are seated on each side a group of thick setae with bifid apices, and some distance above these a pair of stiff, pointed setae. The flagellum is held against the concave sides of this prominence by the first pleopods, passing between the two groups of setae, and is thus guided in towards the mid-line of the venter, passing the second pleopods. The upper seta of the ramus of the last-named apparently serves as a lateral guide to the lash, while in some examples the lower seta crosses its fellow of the opposite pleopod below the flagella. Beyond the second somite the two flagella lie side by side in the ventral gutter of the pleon. The third to fifth somites each bear, near posterior end, two groups (one on each side of the channel) of three unequal rod-like setae, the longest of which is furnished with

plumes directed inwards; these setae possibly assist to retain the lashes in the ventral groove.

Anchistylis similis sp. nov.

Ovigerous female—Carapace much as in *waitei* but with antero-lateral angle rounded, feebly dentate and without prominent tooth; a depression at antennal border margined posteriorly by a ridge which is met by the very feebly serrate dorso-lateral ridge; on dorsum the area between the ridges is slightly excavate, with a low tumidity on each side of the hollow. Ocular lobe wide, with eyes ill-defined, but discernible as three areas more opaque than surrounding chitin.

Pedigerous somites as in *waitei* but anterior margin of fifth somite with smaller serrations.

Telson half as long as sixth pleon somite and not much more than one-third as long as peduncle of uropod.

Second antenna as in *waitei* (fig. 21) but first pair with accessory flagellum a little longer.

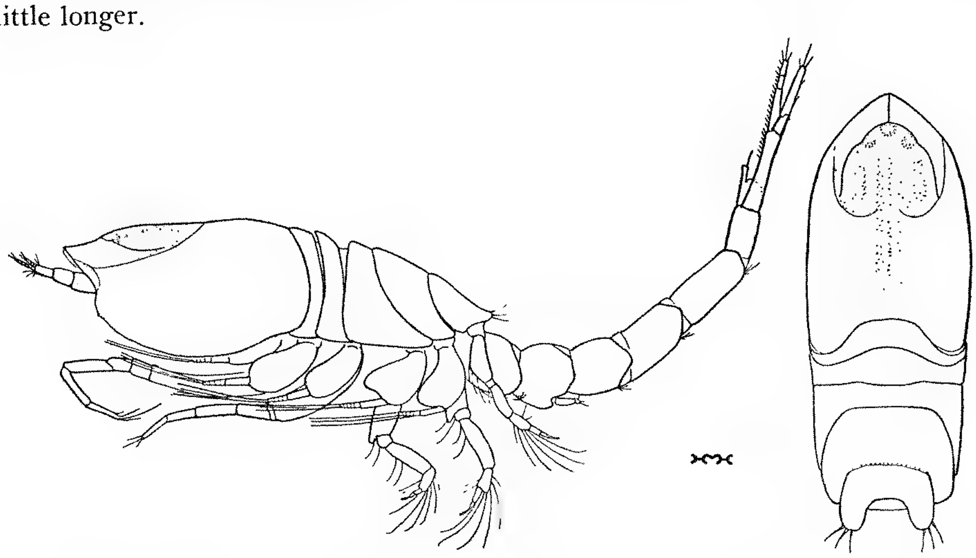

Fig. 23
Anchistylis similis, paratype male; lateral view and cephalothorax from above (x 23).

Mandibles with 10 and 11 spines in the row, the last two or three short and slender.

Nine digitiform branchial lobes, one reflexed, the last two very small.

Basis of third maxilliped much less than half as long again as remaining joints together and not much longer than exopod; with external apical angle not produced beyond level of distal margin of ischium.

First peraeopod as in *waitei*, with the basis as long as or a little longer than rest of limb.

Second peraeopod with basis as long as remainder of limb without the dactylus; ischium distinct; merus, propodus and dactylus subequal in length, carpus a trifle longer.

Peduncle of uropod about as long as the subequal rami; first joint of endopod more than twice as long as second, which is not quite as long as third; inner margin with a few spines near distal end, the rest of this edge with fine setae.

Length, 3·5 mm.

Adult male—Carapace a little less than one-third of total length of animal, longer than pedigerous somites together and a little wider than deep; as in the female the antero-lateral angle lacks the acute tooth present in both sexes of *waitei*. Ocular lobe very wide, with the three corneal areas large and distinct.

Pleon distinctly shorter than cephalothorax; fifth somite not much longer than fourth but longer than any of the others and more than half as long again as fifth; apical spines of telson about half as long as the somite.

Antennae as in male of *waitei*.

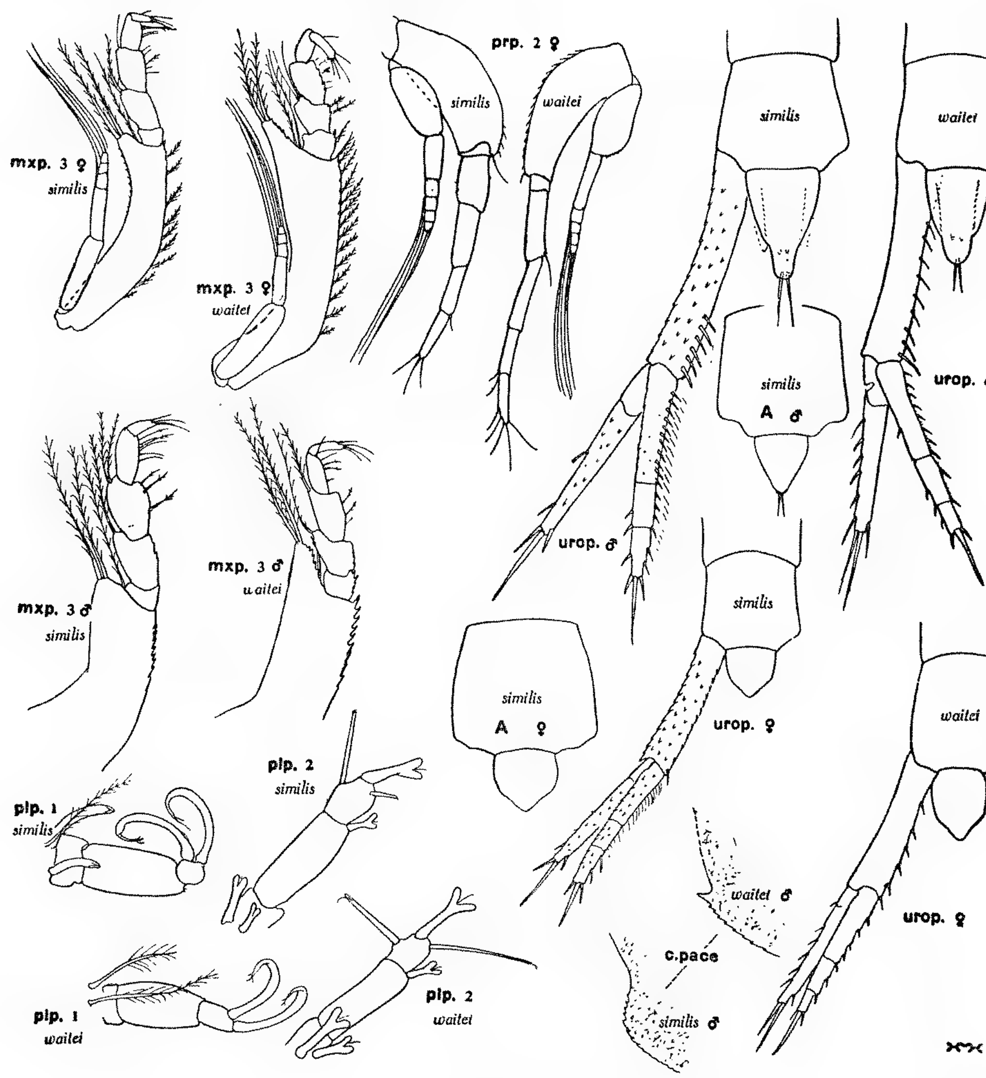

Fig. 24

Anchistylis similis, appendages of paratypes adult male and ovigerous females with those of *A. waitei* for comparison; c. pace, antennal angle (x 55); mxp. and prp., third maxilliped and second peraeopod (x 55); plp., pleopods (x 120); urop., uropod with sixth pleon somite and telson (x 55). A, Sixth pleon somite and telson of *A. similis*, male and female, from Tasmania (x 55).

Third maxilliped with basis nearly twice as long as rest of limb, with external distal angle much less produced than in *waitei* (*cf.* mxp. 3 of males in fig. 24). Basis of first peraeopod a little longer than remaining joints together, that of second not quite as long as rest of limb.

Second and third legs not widely separated as in female.

Peduncle of uropod a little longer than rami, with inner spines near distal end; joints of endopod of same proportions as in female.

Length, 4 mm.

Loc.—New South Wales: Cronulla, 8 feet, on sand (type loc., K. Sheard, submarine light, Sept. 1942). Tasmania: St. Helens Point, 4-5 fms., on clean sand (W. S. Fairbridge, submarine light, Jan. 1945). South Australia: St. Vincent Gulf, off Glenelg (H. M. Cooper, submarine light, Nov. 1944). Types in S. Aust. Museum, Reg. No. C.2730-2731.

The telson of some examples (Tasmania) is relatively smaller than in others (fig. 24, A), and there is some variation in the total length of the animal.

The pleopods of a few of the males of *waitei* and *similis* from different localities have been critically examined. There is some slight variation in the setae of the body, and in *similis* the lower (or anterior) seta of the ramus of the second pleopod seems always to be shorter than in *waitei,* or may even be absent.

Males usually predominate in the available takings of both *waitei* and *similis,* but in a submarine light haul in Tasmania Mr. Fairbridge secured a large number of females together with some males. Many of the females are 4 mm. to 4·5 mm. in length and have just moulted; the brood-pouch is fully developed but empty and the ovaries are swollen with large eggs (see also *Cyclaspis usitata* Hale, 1944, 124, and *Glyphocuma bakeri* Hale, 1944 a, 273).

In both *waitei* and *similis,* some examples in soft condition have the carapace curiously inflated and expanded; this is probably due to the effect of the preservative.

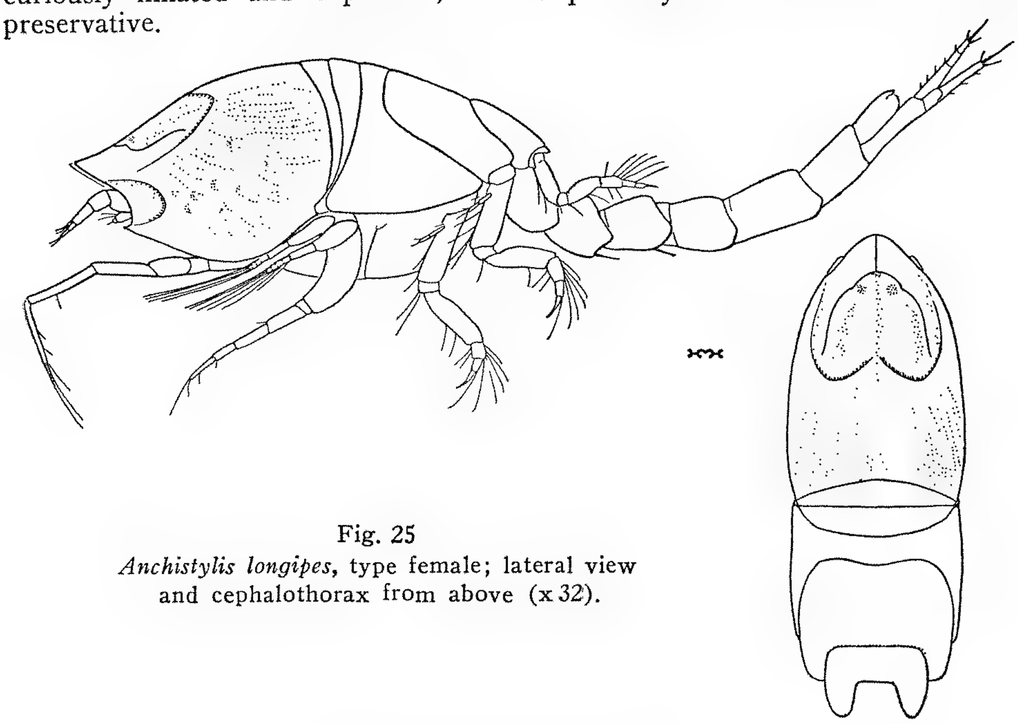

Fig. 25
Anchistylis longipes, type female; lateral view and cephalothorax from above (x 32).

Anchistylis longipes sp. nov.

Female with developing marsupium—Carapace two-sevenths of total length of animal and a little longer than pedigerous somites together; its depth is about three-fourths the length and is equal to the breadth; carinae, etc., much as in genotype; the curved, anterior, dorso-lateral ridge on each side is serrate

posteriorly but the teeth die away towards the front and the ridge itself becomes very faint near that which marks off the antennal area. Antero-lateral margin shallowly concave, finely dentate, and antennal angle produced as acute tooth. Pseudorostrum rounded as seen from above, subacute in front as viewed from the side; lobes meeting for a distance equal to one-sixth of total length of carapace. Ocular lobe wide, with three ill-defined, whitish lenses.

First and second pedigerous somites, as in the other species, shorter than the others; pleural parts of first concealed by those of second, which extend to the carapace; third somite short dorsally but greatly expanded fore and aft on

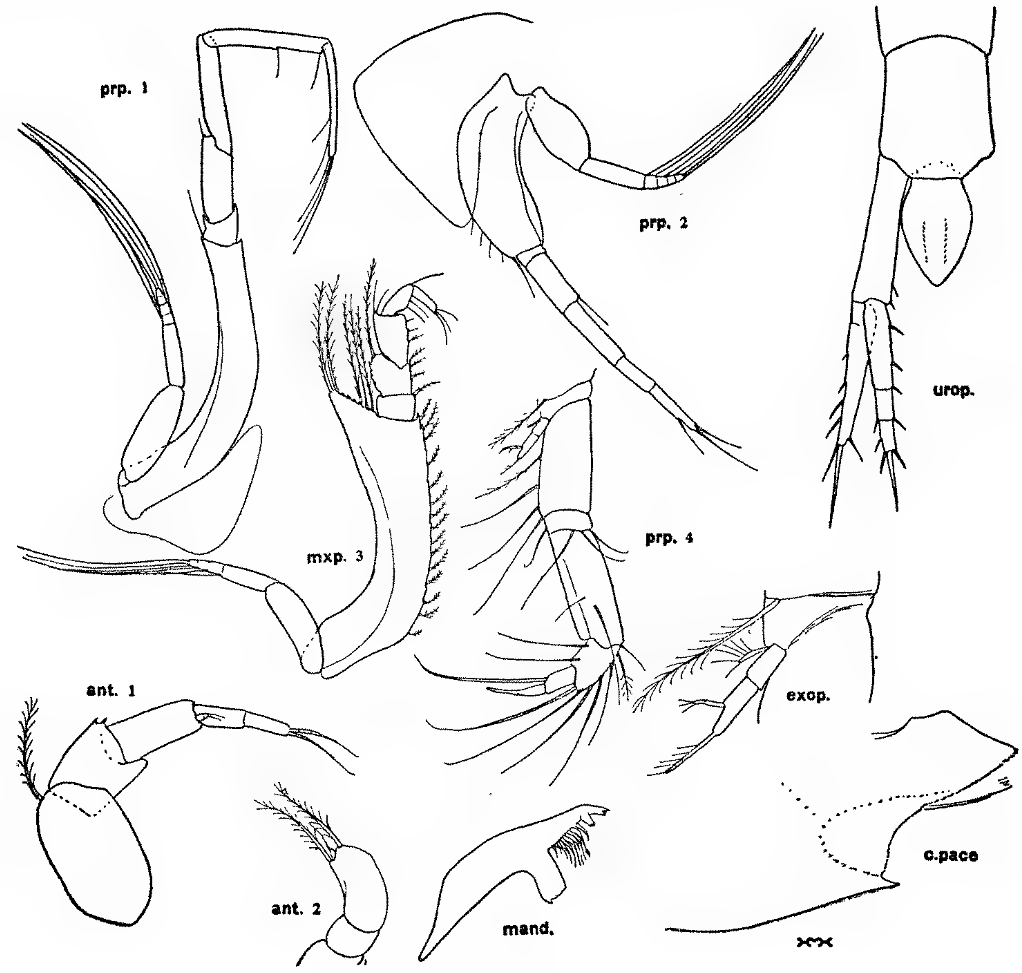

Fig. 26
Anchistylis longipes, type female; c. pace, antero-lateral margin of carapace and antennal angle (x 55); ant., first and second antennae (x 120); mand., mandible (x 55); mxp. and prp., third maxilliped, and first, second and fourth peraeopods (x 55); exop., exopod of fourth peraeopod (x 120); urop., uropod with sixth pleon somite and telson (x 55).

the sides, where it reaches almost to anterior margin of second; anterior edge of fifth somite finely denticulate on back.

Pleon a little shorter than cephalothorax; fifth somite little longer than sixth which is longer than wide; telson large, elongate, cordate, without post-anal part, about three-fourths as long as either sixth somite or peduncle of uropod.

First antenna stout, the first joint of peduncle as long as second and third together; flagellum as long as last peduncular joint, composed of two stout equal joints; accessory lash minute, two-jointed.

Mandible with 10 and 11 spines in the row.

Third maxilliped with basis more as in *waitei* than in *similis;* it is more than half as long again as rest of limb and the external distal part is expanded and produced forwards to level of apex of ischium; exopod much shorter than basis.

First peraeopod with carpus reaching well beyond antennal angle and propodus beyond tip of pseudorostrum; basis only two-thirds as long as remaining joints together; carpus, propodus and dactylus are about equal in length, each as long as ischium and merus together.

Second peraeopod with basis as long as rest of limb without dactylus; carpus almost as long as merus and the distinct ischium together, three-fourths as long again as propodus and a little longer than dactylus.

As in the other species the first and second peraeopods have well-developed exopods, the third and fourth with small two-jointed exopods, with indication of the division of the second segment into two parts (fig. 26, exop.).

Peduncle of uropod about as long as the subequal rami, with a couple of distal spines on inner margin; endopod with first segment three times as long as second which is equal in length to third; inner spines of joints three, one and one; terminal spine of endopod shorter than that of exopod and no longer than last two joints of its ramus.

Length, 3·2 mm.

Loc.—South Australia: Spencer Gulf, Memory Cove, 3 fms. (K. Sheard, submarine light, Feb. 1941). Type in S. Aust. Museum, Reg. No. C.2737.

Summary

The majority of the Australian Diastylids so far obtained are referable to *Gynodiastylis* Calman and allied genera. Of the others, herein dealt with, all but two species belong to *Paradiastylis* Calman, *Dimorphostylis* Zimmer and *Anchistylis* gen nov., in which the males have the basis of the first to fourth peraeopods conspicuously expanded. The new genus is noteworthy in that it has the pleopods remarkably modified.

Species regarded as new are *Leptostylis recalvastra, Paradiastylis mollis, Dimorphostylis subaculeata* and var. *praecox, D. inauspicata, D. tasmanica. D. colefaxi, D. tribulis, Anchistylis similis* and *A. longipes.*

Notes are given concerning the female of *Dimorphostylis cottoni* Hale and the male of *D. vieta* (Hale), neither of which was previously described in detail, and the description of the male of *D. australis* Foxon is amplified.

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SCAPOLITIZED DOLOMITES OF YANKANINNA

BY D. MAWSON AND W. B. DALLWITZ (READ 14 JUNE 1945)

Summary

While investigating the thick series of Proterozoic sediments exposed on Yankaninna and Umberatana sheep stations, in the North Flinders Ranges, we came across an unusual and quote notable occurrence of scapolite, the recording of which is the main object of this contribution. The location of Umberatana is shown on the regional map appearing on page 24 of this volume. We submit herewith a local map, which shows the neighbourhood of Yankaninna (330 miles north of Adelaide) and its relation to Umberatana. The rock formations thereabouts are illustrated by the cross-section on page 213, which refers to the line A to B on the map.

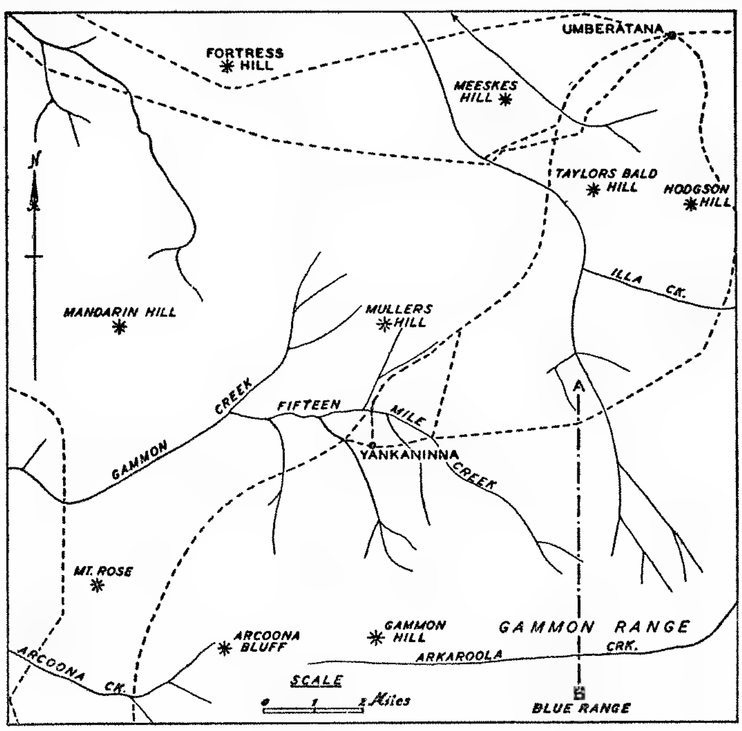
SCAPOLITIZED DOLOMITES OF YANKANINNA

By D. Mawson and W. B. Dallwitz

[Read 14 June 1945]

Plates XIV and XV

While investigating the thick series of Proterozoic sediments exposed on Yankaninna and Umberatana sheep stations, in the North Flinders Ranges, we came across an unusual and quite notable occurrence of scapolite, the recording of which is the main object of this contribution. The location of Umberatana is shown on the regional map appearing on page 24 of this volume. We submit herewith a local map, which shows the neighbourhood of Yankaninna (330 miles north of Adelaide) and its relation to Umberatana. The rock formations there-



abouts are illustrated by the cross-section on page 213, which refers to the line A to B on the map.

The Gammon Range and the Blue Range to the south of it constitute a massive quartzite block. In the former the strike ranges between 70° to 75° E. of N. (true). This quartzite formation extends across the country to the east from Arcoona Bluff to some eight miles beyond Gammon Hill. The succession of strata to the north of the range conforms in a general way with the above direction of strike. The angle of dip, however, falls off to the north from near verticality in the Gammon Range until an anticlinal axis is reached on the line joining the point A of the section (see map) to Mandarin Hill (pl. xiv, fig. 1), to the north of this axis the sediments dip to the north.

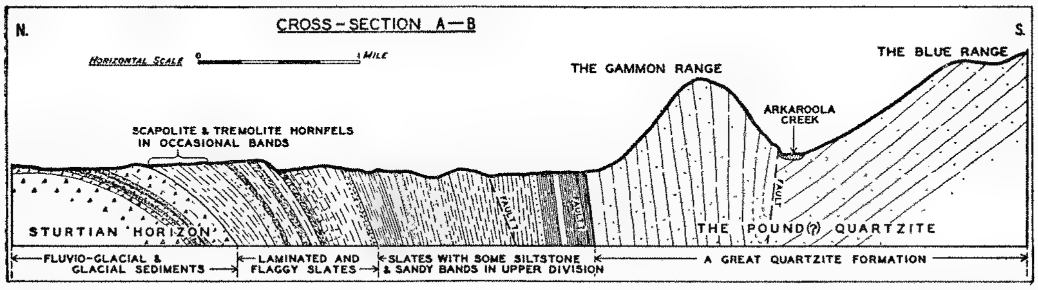
The notable development of tillite and fluvioglacial beds is accepted as the Sturtian glacial horizon, and consequently serves as a valuable datum horizon in developing the stratigraphy of the district. Many years ago the late Mr. W. B.

Greenwood, of Umberatana, drew the attention of one of us to the occurrence of tillite in the neighbourhood of Yankaninna, namely at the Mount Rose Copper Mine and at Muller's Hill.

Continuing to the north of our present line of section, during our recent reconnaissance, we met the tillite again at Taylor's Bald Hill. Further to the north beyond that point, we traversed a great thickness of sediments for some eight miles across the strike, meeting some narrow fluvioglacial horizons but no repetition of strong tillite.

GEOLOGICAL CROSS-SECTION AT YANKANINNA

A geological section across the strike of the country from the summit of the Blue Range to the anticlinal axis to the north is figured herewith. The quartzite ridges stand out in bold relief, the crest of the first range, the Gammon Range, being about 685 feet above the ground level at its base; the second range, the Blue Range, reaches some 300 feet higher. The true thickness of this quartzite was not ascertained owing to the presence of faulting, but it is certainly of the order of several thousand feet with a possible upper limit of 5,000 feet.



The succession of sediments met with in descending order below the Gammon Range quartzite is set out below; the thicknesses stated are reduced true values. Disturbances suggesting strike-faulting were observed in the first three items, consequently the figures relating thereto may not be significant. Below that horizon we have no reason to doubt but that the succession is undisturbed by any serious dislocation.

	Feet
Gammon Range quartzite (several thousand feet).	
Alternations of sandstone and slate	1,820
Slates	2,590
Flaggy slates and siltstones	2,300
Clay slates	920
Limestone	60
Sandstone and siliceous slates	120
Hard flaggy slates	1,080
Alternations of laminated slates and limestones, with occasional horizons of intraformational breccia	690
Laminated slates with intraformational puckering	1,830
Laminated slates with recurrent calcareous bands. Occasional horizons exhibit the "spots" of incipient thermal metamorphism	420
Laminated slates with calcareous horizons; the latter exhibiting varying degrees of conversion to tremolite hornfels and scapolite hornfels	1,100
Fluvioglacial muds with erratics	609
Tillite	72
Fluvioglacial grit	12
Fluvioglacial siliceous grits with erratics	120
Tillite with large boulders (continues down beyond range of section)	40+
	13,783

Only the upper 850 feet of the glacial sediments is exposed where we were; but in this section some quite typical moraine-type of tillite is included. Boulders up to two feet in length are frequent. One ice-scratched and striated boulder met with measured 66 by 48 by 45 inches. The photograph (pl. xiv, fig. 2) shows one of the largest erratics.

For the most part the glacial sediments are very firmly welded, having been subjected to the same degree of thermal metamorphism as was responsible for the development of tremolite and scapolite in the overlying beds.

Proceeding along the anticlinal axis towards Mandarin Hill the glacial beds wing out to the south and to the north and an underlying series of dolomitic sediments (evidently to be correlated with the Beaumont dolomites) makes its appearance.

Reverting to a consideration of the scapolite and tremolite hornfels developed in the beds overlying the tillite, we noted that the degree of metamorphism decreased towards the west. In our contribution (Proc. Roy. Soc. S. Aust., **68**, 191-209) dealing with the leucogranite intrusions at Giant's Head it was obvious that the tremolite- and scapolite-bearing hornfels, developed from calcareous and dolomitic sediments closely associated with the tillite horizon, owe their metamorphism to the adjacent igneous intrusions. Chlorine-rich gaseous or liquid emanations from some igneous source appear to have been necessary for the development of scapolite in this new area also. Thus it would appear that the intrusive granitic magma outcropping near Umberatana must extend below ground to within several miles of the Yankaninna homestead, for to its activities as a metamorphosing agent we ascribe the production of the scapolite.

The development of scapolite and tremolite in calcareous and dolomitic bands in the laminated slates above the glacial beds is well marked immediately above the glacial horizon and recurs at intervals throughout more than 1,000 feet of the immediately overlying sediments.

Individual bands thus affected vary in thickness from several feet to many yards. They are dark-coloured, owing to the presence of much fine graphite and some biotite (in part phlogopitic) discernible only in microscope sections.

In the case of some of the outcrops large crystals of scapolite stand out in bold relief as a result of weathering under arid conditions: rock [5973] described below and figured on pl. xv is an example of such. Associated with the scapolite-bearing marbles are others rich in tremolite, as [5155] and [5157] described below.

PETROGRAPHIC DESCRIPTIONS OF THE SCAPOLITE AND TREMOLITE MARBLES

Graphitic scapolite-siderite-marble [5973]

A dark grey, almost black, rock consisting of a very fine-grained matrix of calcite in which are embedded abundant idioblasts of scapolite. On the weathered surface these stand out in a spectacular manner (pl. xv, fig. 1), many individuals being well over 0·5 cm. in cross-section; some weathered in relief are seen to exceed 2 cm. in length.

Microscopic Observations—The texture is maculose with porphyroblasts of scapolite in a finely granoblastic groundmass.

The groundmass consists of fine-grained calcite, quartz (some albite may be present, but it cannot be definitely identified on account of the fineness of grain), graphite, and biotite, which is pleochroic from light brown to pale yellow. In addition to scapolite the groundmass carries well-shaped rhombs of siderite which measure, on the average, about 0·7 mm. by 0·6 mm. These rhombs often have

included in them graphite, biotite, etc., of the groundmass. Pockets and veinlets of coarser, segregated, relatively clear calcite are not uncommon; they are especially developed around scapolite grains.

The scapolite porphyroblasts contain very abundant inclusions of finely granular biotite, quartz and graphite, and sometimes veinlets and patches of goethite and grains of black iron ore; occasionally irregular pockets of calcite are also found therein. The graphite is usually in thin wisps whose length is parallel to the *c*-axis of the host. The crystals are mottled and are bordered by a narrow, marialitic shell, easily recognised by its lower D.R. In one case narrow veinlets of marialitic scapolite cross a large crystal of that mineral in a direction parallel to (001).

We attribute the mottling illustrated in these porphyroblasts to the continued introduction of sodium and chlorine, an explanation which accounts for the outer marialitic zone in the case of scapolite in some of the Tourmaline Hill rocks described recently (see Mawson and Dallwitz, this volume, pages 22 to 49). The original more meionitic scapolite has been attacked and replaced.

The prismatic faces of the crystals are clear-cut, yielding perfectly shaped sections across the *c*-axis. Terminal faces are always wanting, the crystals merely ragging out at either end of the prism zone. In some individuals thin, straight fingers of the marialitic scapolite penetrate clear marginal calcite and in others short rods of calcite are embedded in the marginal shell; both these cases are fundamentally the same, because in the first calcite is in excess, while in the second scapolite preponderates.

Basal sections of scapolite idioblasts may contain inclusions arranged in a manner commonly observed in chiastolite (pl. xv, fig. 2). This feature, as well as the general abundance of inclusions, testifies to very quick growth. The prism faces of some of the idioblasts exhibit a concave curvature.

Dolomitic tremolite-marble [5157]

A mottled dark grey rock composed very largely of carbonate minerals. The only other constituent clearly defined in the hand-specimen is tremolite, which usually occurs in bladed and needle-like crystals, often in radiating groups; some of these are almost 2 cm. long, with an average width of about 1 mm. Lighter coloured pockets of coarsely crystalline carbonate minerals in crystals as much as 1 cm. across and often with curved cleavage faces are distributed through the general very fine-grained dark base.

Microscopic Observations—Both texture and distribution of the minerals are markedly uneven. The greater area of the microscope slide is occupied by very fine-grained calcite representing the but little altered original limestone. Coarsely recrystallized calcite and dolomite occurs in pockets; in these latter irregularly distributed patches of graphite are usually found. These pockets are commonly associated with tremolite-rich areas.

Not all of the tremolite is in long crystals, some being of normal habit. It is in colourless euhedral to subhedral crystals. The maximum measured extinction angle is 18°. It is frequently, though not invariably, mottled under crossed nicols; this feature is best seen in transverse sections, in which the "mottling" takes the form of zoning; the inner parts, in sections of normal thickness, showing first-order yellow and the outer zone second-order blue to yellow-green, due to the richness of the latter in MgO. Simple twinning is occasionally seen. Inclusions of graphite, though not abundant, are usually present, but they are irregularly distributed and may be entirely absent in part of a crystal. Calcite also forms inclusions, but such are relatively rare.

The dolomite grains themselves are bordered by a narrow black band of concentrated graphite, which the mineral evidently succeeded in expelling almost

Fig. 1

Fig. 2

PORPHYRITIC POTASH-SODA MICROGRANITES OF MOUNT MONSTER

By D. Mawson and E. R. Segnit

[Read 14 June 1945]

INTRODUCTORY REMARKS

Mount Monster is a hill rising about 150 feet above the surrounding mallee-covered plain seven miles south of the township of Keith, 130 miles south-east of Adelaide (see regional map, Trans. Roy. Soc. S. Aust., 1944, **68**, (2), 193). Over a wide area in the surrounding district there is a covering of Recent sand and soil, with no rock exposed beyond the outcrops to be described, an occasional inlier of granite encountered at widely spaced intervals, and boulders and crusts of surface travertine. At comparatively shallow depth below the surface, Tertiary limestone is usually met with before bottoming on granitic igneous rocks and associated schists. The age of the latter fundamental formation is thought to be not later than Middle-Cambrian.

The existence of an occurrence of quartz-feldspar-porphyry at Mount Monster was recently recorded (Mawson and Dallwitz, Trans. Roy Soc. S. Aust., 1944, **68**, (2), 191; the object of the present contribution is to furnish a detailed account of other microgranites outcropping in the area.

THE IGNEOUS OUTCROPS

The outcrops, shown on the plan herewith, are distributed in two groups, namely, those at and around Mount Monster and those forming a chain to the south and south-east. Except in the case of Mount Monster itself they are inconspicuous, rising only from a few feet to a maximum of 50 feet above the lowest ground surface in the neighbourhood. The south-easterly chain consists of nobbly outcrops with a tendency to elongation and cleavage in a general north and south direction.

The Mount Monster mass occupies an area of about 450 yards by 500 yards. Near the summit there is a 40-ft. high rock face. The trend of the grain of the rock is about W. to E.

Outcrops 1, 2, 3, 4 and 7 are all very much alike, though the rock of outcrop 4 has, possibly, a somewhat greater proportion of base to phenocrysts. Specimen [5797], typical of outcrop 7, is described on page 221, and a rather similar rock [5479] from outcrop 4, is dealt with on the same page.

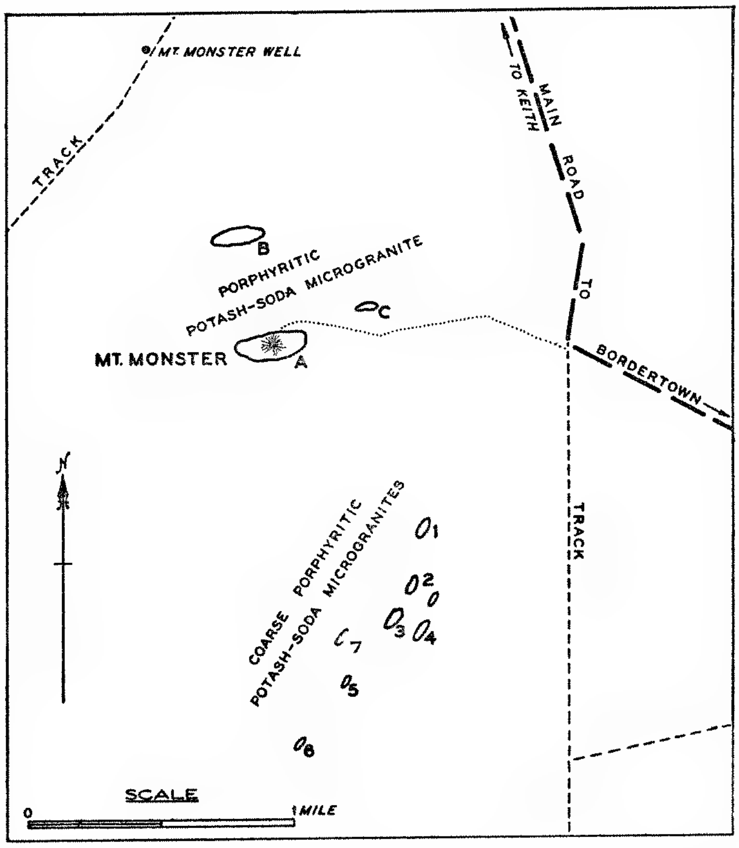
Portion, at least, of outcrop 5 is remarkable for the high degree of deuteric alteration suffered by it, although, doubtless, it was initially very similar to the rock [5797]. An example of this phase [5778] is described on page 219.

The remaining variant is that of the farthest south, outcrop 6. The rock from that locality can be distinguished at a glance on account of its lighter colour. Specimen [5777], which is typical of it, is described on page 221.

The petrological descriptions to follow indicate a general similarity of type throughout and illustrate the effect of attack on already formed minerals by late magmatic residual liquors and gases.

There is, however, in the case of the rock of outcrop 6, a more fundamental difference, for in it the orthoclases, which are to a minor degree microperthitic, are markedly tabular and in some parts of the outcrop tend to be aligned as by flow structure. Also there is much micrographic development as a late crystalliza-

tion in the groundmass. Finally, some of the calcite occupying spaces between earlier formed grains in the rock has the appearance of having crystallized from the late magmatic mother liquors.



GENERAL CHARACTER OF THE ROCK TYPES

THE FELSITIC QUARTZ-FELDSPAR-PORPHYRY OF MOUNT MONSTER

The rock composing Mount Monster itself and the outcrop to the north of it is distinct from that of the group of minor outcrops distant one mile and more to the south-south-east. That of the former area is more uniform in character as well as being characterised by phenocrysts of smaller dimensions and a devitrified base of finer texture.

A typical specimen from the summit of Mount Monster [4426] has already been briefly described (Mawson and Dallwitz, 1944, *loc. cit.*). Dallwitz's analysis of that potash-soda-microgranite is repeated herewith in the table on page 219. It is made up of phenocrysts of pinkish-buff coloured orthoclase, somewhat lighter coloured albite and obviously smoky quartz embedded in about an equal volume of a liver-brown devitrified felsitic base.

A second specimen [4425] from the main Mount Monster mass has now been sectioned but discloses no new features.

The rock [4424] representative of the large body (outcrop B) situated to the north of Mount Monster differs in no material features from [4426]. It is noteworthy, however that all three of these specimens agree in indicating that the rocks of this group have not suffered so seriously from secondary deuteric and subsequent changes as is a feature of the minor outcrops to the south-south-east. For example, the orthoclases of the former group are usually fresh and clear within, having suffered alteration only in their peripheral areas.

THE SOUTHERN GROUP OF PORPHYRITIC MICROGRANITES

The rocks of these small but numerous outcrops represent a considerable range in appearance. It is found that they can be grouped under three slightly variant forms. In the petrological descriptions to follow [4579] and [5797] are the more general forms, [5778] is modified by late magmatic reaction and [5777], which is in the extreme southern end of the intrusion, is a granophyric end-product in the consolidation of the magma.

TABLE OF ANALYSES

	I	II	III	IV
SiO_2	73·77	72·50	74·44	69·42
Al_2O_3	13·06	14·02	12·94	15·01
Fe_2O_3	0·72	0·92	1·35	0·36
FeO	1·43	1·24	0·99	2·42
MnO	0·05	0·04	—	—
MgO	0·12	0·23	0·16	0·12
CaO	0·89	0·77	0·53	1·63
Na_2O	3·55	3·47	3·53	3·48
K_2O	5·44	5·24	4·79	5·71
H_2O+	0·57	0·73	0·55	0·68
H_2O-	0·11	0·18	0·01	0·13
P_2O_5	0·08	0·06	0·05	0·11
TiO_2	0·18	0·08	0·26	0·31
ZrO_2	0·01	0·04	—	—
Cr_2O_3	nil	—	—	—
BaO	0·06	0·07	—	—
SrO	0·01	—	—	—
CO_2	0·16	0·80	0·20	0·81
F	0·04	0·08	0·04	0·07
Cl	trace	—	—	—
SO_3	nil	—	—	—
S	0·02	—	—	—
	100·27	100·47	99·84	100·26
Less O for F	0·02	0·03	0·01	1·02
Total	100·25	100·44	99·83	100·24
Sp. Gr. at 15° C.	2·613	2·595	2·742	2·580

I. Porphyritic potash-soda-microgranite (porphyritic quartz-feldspar-porphyry) [4426], the rock forming the mass outcropping as Mount Monster itself; from the Summit. Analyst, W. B. Dallwitz.

II. Autometamorphosed porphyritic potash-soda-microgranite [5778] from a portion of outcrop 5 (see plan, p. 218) of the south-eastern belt of outcrops, Mount Monster locality. Analyst, E. R. Segnit.

III. Porphyritic potash-soda-microgranite [5479] from outcrop 4 of the south-eastern belt of outcrops, Mount Monster locality. Analyst, D. J. Guppy (with minor additions by E. R. Segnit).

IV. Porphyritic granophyric potash-soda-microgranite [5777] from outcrop 6 of the south-eastern belt of outcrops, Mount Monster locality. Analyst, J. H. Shepherd (with minor additions by E. R. Segnit).

AUTOMETAMORPHOSED PORPHYRITIC POTASH-SODA MICROGRANITE [5778] from Outcrop 5

This is a markedly porphyritic rock in which large brick-red, idiomorphic phenocrysts of orthoclase, some greyish-white plagioclase and plentiful small clear quartzes are set in a felsitic brownish-red base. Also some small dark green,

chloritic patches are distributed through the stony base. The orthoclases, which are up to 2 cm. by 0·5 cm. in size, exhibit Carlsbad twinning and not infrequently have an outer zone of plagioclase.

Microscopic Observations—The large orthoclase phenocrysts are observed to be microperthitic; the albite element is in small amount and but faintly recorded. As a result of secondary alteration the large microperthite phenocrysts have, in large measure, been reduced to a reddish, cloudy mass which in places almost obliterates the original structure. Smaller plagioclase phenocrysts have optical characters corresponding to almost pure albite. The plagioclase has had developed in it unoriented flecks of mica (sericitization), but lamellar twinning is still distinguishable.

Quartz phenocrysts are both large and small but seldom exceed 0·4 mm. diameter. They contain abundant inclusions both solid, liquid and gaseous, which are often aligned along definite crystal planes.

Chlorite, with pleochroism X = Y = green, Z = pale greenish-yellow, is of frequent occurrence as small irregular flakes up to 1 mm. in length; these are length-slow and of moderate D.R., which characters combined with the high FeO : MgO ratio disclosed by the analysis (*cf.*, rock [5777]), indicate this mineral to be a chlinochlore rich in iron. There are clear indications that, in most cases at least, this chlorite has developed from primary biotite, though to a minor degree it may represent paramorphs after amphibole.

Magnetite, leucoxenized ilmenite, apatite and zircon occur as small but distinct crystals, the latter is grey and occurs in crystals up to 0·4 mm. diameter. Apatite laths and purple grains of fluorite are both very rare.

The groundmass is a very fine granular aggregate of quartz, about 40%, and altered feldspar with a small amount of chlorite; average grain-size is about 0·05 mm. The feldspar of the groundmass and that of the microperthite phenocrysts have been subjected to the same secondary changes and appear red in reflected light.

Tiny particles of a carbonate mineral which appear in the groundmass and as alteration products of some of the feldspars are a very minor but notable and general constituent. It appears to be calcite with Fe and Mg replacing some of the Ca. This conclusion is indicated by the fact that the rock powder when digested for a few minutes with HCl of 50% dilution had abstracted from it the following, stated in percentage of the rock: Al_2O_3 1·53, Fe_2O_3 0·64, FeO 1·19, CaO 0·70, which suggests that much of the iron is present as the siderite molecule.

It would appear that this porphyritic felsite owes some of its special characters to the action of late magmatic liquids and gases resulting in chloritization and calcitization.

A chemical analysis is submitted in the table on page 219. From this the Norm has been derived as follows. In column I the CO_2 is taken into account in the calculation, but excluded in column II.

	I	II		I	II
Quartz	31·98	29·94	Zircon	0·05	0·05
Orthoclase	30·58	30·58	Siderite	0·81	—
Albite	29·34	29·34	Calcite	1·10	—
Anorthite	—	3·34	Apatite	0·13	0·13
Corundum	2·65	1·53	Fluorite	0·16	0·16
Hypersthene	1·00	2·05	CO_2	—	0·80
Magnetite	1·39	1·39	H_2O	0·91	0·91
Imenite	0·15	0·15	Total	100·25	100·37

C.I.P.W. classification: Class I, order 4, rang 1, subrang 3.

PORPHYRITIC POTASH-SODA MICROGRANITE [5479] from Outcrop 4

This rock is fundamentally not very different from [5778], but here the contrast between the two feldspars and the groundmass is not so pronounced: the perthite is lighter in colour and the plagioclase is pinkish. The main point of difference is that here there is less evidence of late magmatic deuteric change.

Microscopic Observations—An essential difference between this rock and [5778] is that here (1) a light-coloured epidote is abundantly developed as tiny crystal grains as an alteration product of plagioclase, and (2) obvious carbonate minerals are absent. Both feldspars are clouded as in [5778], but crystal grains of epidote up to 0·1 mm. in length are distributed through the plagioclase, which latter corresponds in optical characters with an albite containing only a very small amount of the anorthite molecule. Epidote of the pistasite variety appears as grains up to 2 mm. by 0·5 mm., in association with chloritized relics of original biotite. Other accessory constituents are ilmenite, magnetite, zircon and fluorite (very rare). The plagioclase in this rock is less abundant and smaller in grain than is the case of [5797] and [5778].

A chemical analysis appears in the table on page 219. The composition of the Norm is as follows. In column I the CO_2 is taken into account but excluded from column II.

	I	II		I	II
Quartz	35·28	34·68	Ilmenite	0·61	0·61
Orthoclase	28·36	28·36	Apatite	0·13	0·13
Albite	29·34	28·34	Calcite	0·50	—
Anorthite	0·83	2·22	Fluorite	0·07	0·07
Corundum	1·63	1·12	CO_2	—	0·20
Hypersthene	0·53	0·53	H_2O	0·56	0·56
Magnetite	2·09	2·09	Total	99·93	98·91

C.I.P.W. classification: Class I, order 4, rang 1, subrang 3.

PORPHYRITIC POTASH-SODA MICROGRANITE [5797] from Outcrop 7

In general appearance this rock resembles [5479]; in the hand specimen it differs from [5778] mainly in that the latter has suffered deuteric changes to a more marked degree. The orthoclases are large and tabular in form, up to 1 cm. in length, and the central areas are often light-coloured contrasting with a redder marginal zone. The quartzes are large and black in appearance.

Microscopic Observations—The orthoclases are not microperthitic; the secondary attack resulting in a red dusty appearance has affected the margins only, leaving clear unaltered orthoclase within. There is plenty of porphyritic plagioclase, the crystals often bunched together in a glomeroporphyritic arrangement.

Grains of epidote are present, but calcite is absent. Green chloritic areas are conspicuous, in association with some of which there is a notable concentration of apatite in laths up to 3 mm. in length. Small amounts of zircon and of partly leucoxenized iron-ore are to be observed, but no fluorite appears in the section.

PORPHYRITIC GRANOPHYRIC POTASH-SODA MICROGRANITE [5777] from Outcrop 6

This rock which is typical of the farthest south mass on the line of outcrops is quite obviously different in appearance from any of the others from this locality, in that the felsitic base is light grey in place of the prevailing red-brown of other outcrops. It is, however, like them, a felsitic quartz-feldspar-porphyry, but again it differs in that the orthoclases tend to be tabular and to exhibit a marked fluctional arrangement.

The largest phenocrysts are buff-pink orthoclases, which attain a maximum size of 1 cm. by 0·25 cm. The plagioclases are greyish-white and sometimes intergrown with a little chlorite. Quartz occurs in small dark-grey equidimensional crystals, rarely exceeding 2 mm. diameter.

Microscopic Observations—Of the phenocrysts large turbid idiomorphs of orthoclase predominate; some of them carry a little microperthitic albite. The plagioclase is in smaller individuals, and these are much less affected by turbidity than is the case with the orthoclase. In shape the quartzes range from ragged and rounded to sub-idiomorphic.

The slide reveals that there is an abundant development particularly around the quartz and feldspar phenocrysts, but also in the groundmass, of granophyric intergrowths of these minerals.

The groundmass is in the main a fine-grained aggregate of clear quartz and clouded feldspar. Other minerals are merely accessory.

Chlorite (apparently after iron-rich biotite) is abundant. Its micaceous habit is well developed, facilitating determination of its properties. It is strongly pleochroic; X = Y = green, Z = very pale yellowish-green. D.R. 0·009, R.I. 1·65. Pseudo-uniaxial negative and length-slow. These properties and the high FeO : MgO ratio in the analysis indicate approach to the daphnite-ferroantigorite end of the series, with a composition about FAn_{45} Ant_{15} Dap_{30} Am_{10}.

Calcite is present to a notable extent. It is better crystallized and segregated than in the case of [5778], and is rarely seen in association with the feldspars. It frequently occurs with the chlorite, but does not appear to bear any reaction relation to it. Elsewhere it occurs independently in large crystals, up to 2 or 3 mm. in length. There appears to be no doubt but that much of the calcite in this rock formed in small cavities at a late stage in the crystallization of the residual liquors of the magma.

Epidote is present only to a very limited extent in association with the chlorite. Magnetite, zircon and apatite are accessories.

The chemical composition is given in the table on page 219. The Norm is as stated below, where in column I the CO_2 is taken into account in the calculation, but is excluded in column II.

	I	II		I	II
Quartz	24·84	22·68	Ilmenite	0·61	0·61
Orthoclase	33·92	33·92	Apatite	0·34	0·34
Albite	29·34	29·34	Calcite	1·80	—
Anorthite	1·67	6·67	Fluorite	0·16	0·16
Corundum	2·45	0·61	CO_2	—	0·81
Hypersthene	3·73	3·73	H_2O	0·81	0·81
Magnetite	0·70	0·70			
			Total	100·37	100·38

C.I.P.W. classification: Class I, order 4, rang 2, subrang 3.

SUMMARY

The location of a number of outcrops of porphyritic potash-soda microgranites occurring in the neighbourhood of Keith have been mapped. They are in the nature of quartz-feldspar-porphyries with a felsitic to microcrystalline base and appear to be of the nature of intrusions into the upper crust, but relevant evidence relating thereto is obscured by recent surface formations. A late crystallized phase has a well-developed micro-granophyric texture. Interesting deuteric changes are recorded.

These porphyries belong to the suite of the extensive fluor-granite formation which reappears at intervals from the Mount Lofty Ranges in a south-easterly direction towards the Victorian border. An apparently similar rock occurs near Hamilton in Victoria, suggesting the probability of this belt of rocks extending into western Victoria.

NEW SPECIES OF DIPLURA (INSECTA APTERYGOTA) FROM AUSTRALIA AND NEW GUINEA

BY H. WOMERSLEY, SOUTH AUSTRALIAN MUSEUM (READ 9 AUGUST 1945)

Summary

Family PROJAPYGIDAE, Genus SYMPHYLURINUS Silvestri 1936. Boll. Lab. Zool., Portici., 30, 52,m 1936.
Symphylurinus swani n. sp. *Description* Colour, creamy-white. Head above with medium and short setae, occiput with 5 medium setae on each side, anterior of transverse suture with 3+3 medium setae, behind antennae bases with 3+3, between antennae bases 1 median and medium in length, on clypeus with one long median and 1+1 shorter latero-medial setae; antennae 23 segmented, with the setae and sensillae as in the genus (see Silvestri 1936).

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By H. Womersley, South Australian Museum

[Read 9 August 1945]

Family PROJAPYGIDAE

Genus Symphylurinus Silvestri 1936

Boll. Lab. Zool., Portici., **30**, 52, 1936.

Symphylurinus swani n. sp.

Fig. 1

Description—Colour, creamy-white. Head above with medium and short setae, occiput with 5 medium setae on each side, anterior of transverse suture with 3 + 3 medium setae, behind antennae bases with 3 + 3, between antennae bases 1 median and medium in length, on clypeus with one long median and 1 + 1 shorter latero-medial setae; antennae 23-segmented, with the setae and sensillae as in the genus (see Silvestri 1936).

Thorax: pronotum with 4 + 4 macrochaetae furnished with 1-2 short indistinct subapical barbs, one submedian subanterior and slightly shorter than length of pronotum, one lateral slightly longer than pronotum and 2 + 2 subposterior slightly shorter than pronotum, otherwise pronotum with many short setae; mesonotum with 9 + 9 macrochaetae, 2 + 2 subanterior, 2 + 2 transversely submedian, 1 + 1 lateral and 3 + 3 posterior of which the laterals are slightly longer than the sublaterals, all with 1-3 subapical barbs; metanotum with 5 + 5 macrochaetae of which 3 + 3 are subposterior, otherswise as in mesonotum; praesternum with 2 + 2 medium barbed setae, fork of sternum with 1 + 1, several lateral, 1 + 1 transverse median and 1 + 1 subposterior macrochaetae, all long and with 1-3 barbs.

Legs: tibiae of I with strigulae of 4 spathulate setae at apex; III, trochanter with 2 short ventral macrochaetae; femur with 3-4 dorsal, subanterior 1, inferior 2; tibia with short inferior macrochaetae; tarsi with numerous very short setae, praeapical dorsal setae short, praetarsal claws curved, unequal.

Abdomen: tergite I with 1 + 1 subanterior submedian macrochaetae and 1 + 1 posterior submedian with 1-2 barbs; II with 1 + 1 subanterior submedian, and 2 + 2 posterior; III with 2 + 2 subanterior and 3 + 3 posterior, IV-VII with 3 + 3 subanterior, 1 + 1 lateral and 4 + 4 posterior; VIII and IX with 4 + 4 posterior; X with 1 median long macrochaetae, and 5 + 5 shorter posterior macrochaetae; sternite I, macrochaetae 3+3 anterior, 1+1 lateral and 4+4 posterior, stylets rather more than half length of sternite (72μ), subcoxal appendage slightly longer than stylet (80μ) with ca. 8 short stout apical spines; II-VII macrochaetae 8 + 8, 2 + 2 subanterior, 6 + 6 posterior, stylets as in I; VIII macrochaetae 1 + 1 posterior submedian sublateral; IX macrochaetae 2 + 2 posterior and 2 laterals; X 2 + 2 macrochaetae and 10 + 10 shorter setae.

Cerci: 11-segmented, I short and annuliform, II-IV about one-third length of entire cerci together, each segment from I-IX with 2-transverse series of 6-setae, X and XI with 1 series.

Length 2·475 mm., width of head 0·48 mm., antennae 1·35 mm., leg III 0·9 mm., cerci 0·675 mm.

Loc.—A single female from under a stone, Atherton, North Queensland, 20 April 1945 (D. C. S.).

Remarks—The first record of *Symphylurinus* and of the Projapygidae from Australia. The genus was previously known only from India, China, West Africa and South America.

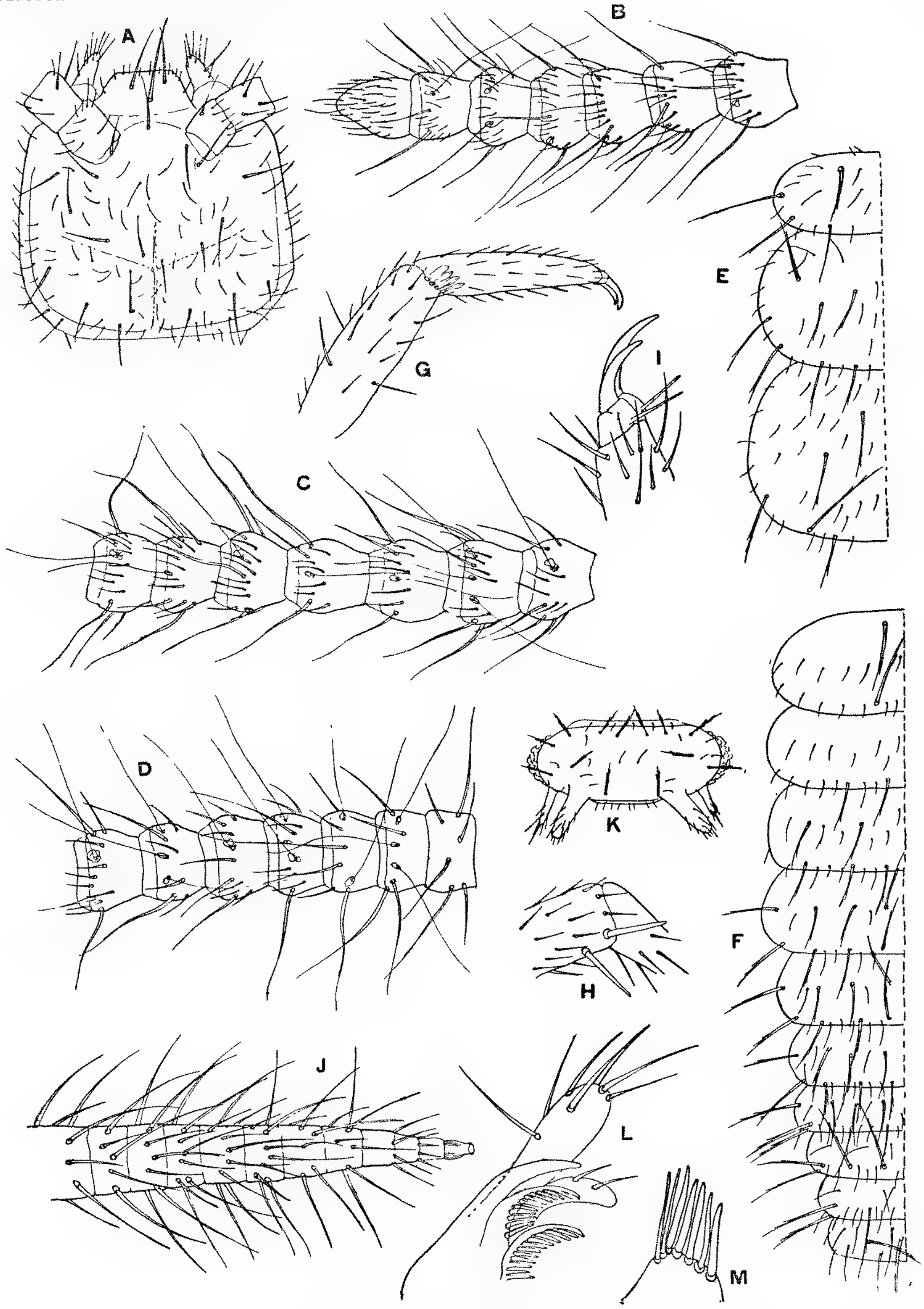


Fig. 1 *Symphylurinus swani* n. sp.
A, head in dorsal view; B, C, D, antennae in three sections B, apical, C, medial, D, basal; E, thoracic tergites; F, abdominal tergites; G, tibia and tarsi of leg I; H, apex of tibia III; I, tarsal claws leg I; J, cerci; K, urosternite I; L, maxilla; M, sensillae on submedian area of mentum.

Family JAPYGIDAE
Subfamily PARAJAPYGINAE
Genus PARAJAPYX Silv. 1903

Annu. Mus. Napoli (n.s.), **1**, (7), 3, 1903.

Parajapyx queenslandica n. sp.

Fig. 2 A-B

Description—Colour, creamy-white except for the well-chitinised yellow Xth abdominal somite and the forceps. Head rather longer than wide, with ca. 18 + 18 short subequal setae, suture lines not evident. Eyes absent. Antennae

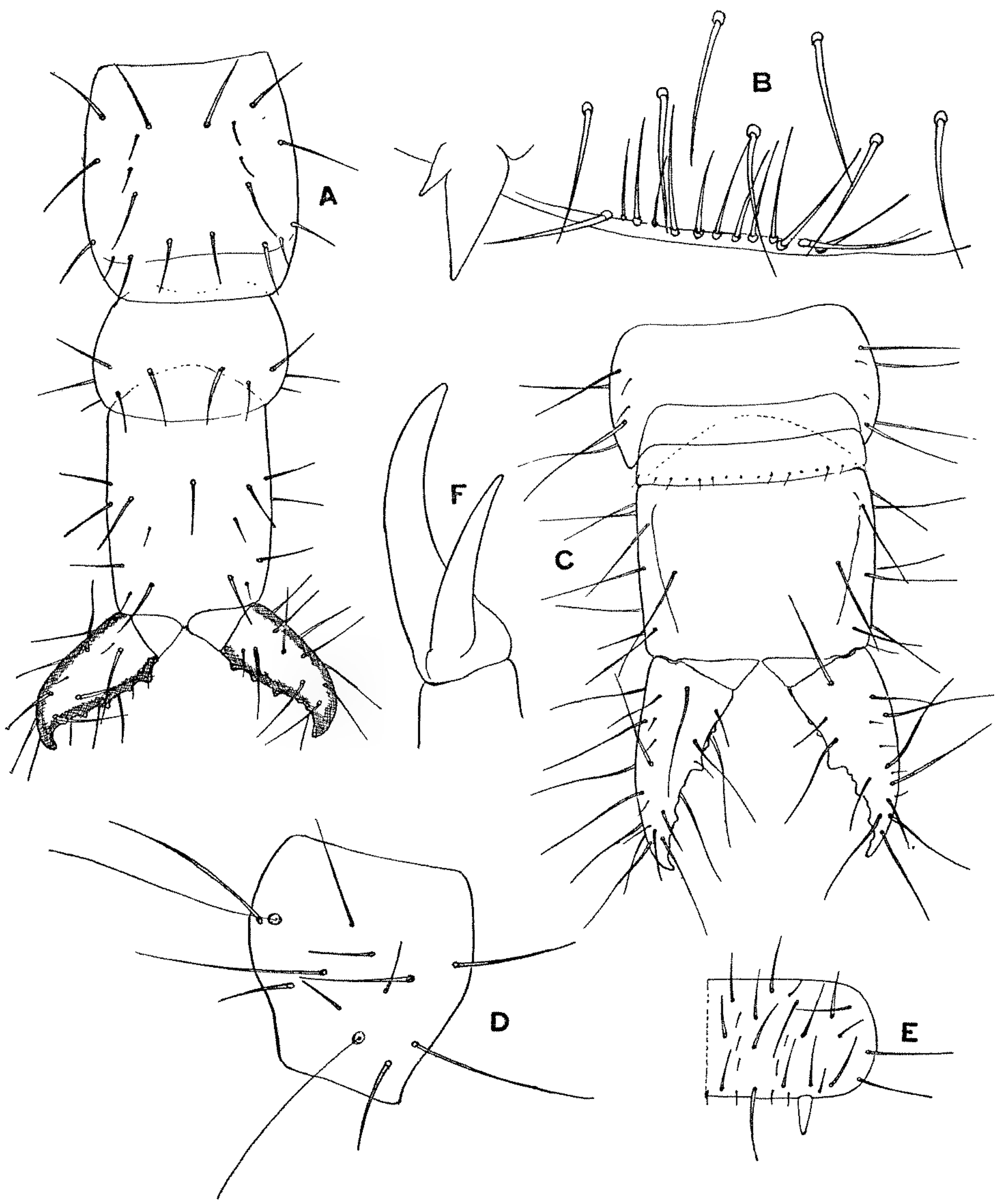


Fig. 2 A-B—*Parajapyx queenslandica* n. sp.: A, abdominal tergites VIII-X and forceps; B, subcoxal organ on urosternite I. *Indjapyx goodenoughensis* n. sp.: C, abdominal tergites VIII-X and forceps; D, antenna IV from above; E, right half urosternite V; F, claws of leg III.

18-segmented, entirely without sensillae. Labial palpi wanting. Mouth-parts as in the genus.

Thorax: pronotum with 6 + 6 short to longer setae, a median transverse row of 3 + 3, the laterals the longest, and a subposterior row of 3 + 3, the middle one on each side being the longest; mesonotum with 24 short and longer setae, 1 + 1 anteromedian, 4 + 4 longer with the outer the longest, then 2 + 2 short, followed by 3 + 3 short subposterior; metanotum with 26 short and longer setae, 2 + 2 antero-median, the inner members the longer, then 4 + 4 the outer the longest, then 2 + 2 short, then 4 +4 longer, followed by 3 + 3 short and posterior; prosternum with 3 + 3 praesternal, then 3 + 3, then 1 median plus 1 + 1 furcal, then 2 +2; mesosternum with 4 + 4, then 1 median plus 1 + 1 furcal, then 2 + 2 subposterior; metanotum 5 + 5 praesternal, then 1 median plus 1 + 1, then 4 + 4, then 1 median plus 1 + 1 furcal, then 2 + 2 subposterior.

Legs short, claws subequal with a pair of fine setae from the praetarsus.

Abdomen: tergites I-VII with four rows of short to longer setae; VIII with 11 + 11 setae, fairly long, 4 + 4 subanterior, the first and third on each side long, the others very short, 1 + 1 lateral long, 1 + 1 sublateral and very short, then 1 + 1 long submedian, then 4 + 4 subposterior, the third on each side very short; tergite IX much shorter than VIII or X with a subposterior row of 4 + 4 long setae; X and forceps as figured. Sternites I-VII with four transverse rows of 6-8 short setae, VIII with 8 + 8 short and longer setae, IX with 4 + 4 subposterior short and longer setae. All setae simple.

Sternites II and III with the usual large round paired vesicles.

Stylets (*cf.* fig. 2 B) small, conical and with a smaller outer accessory cone. Subcoxal organs on sternite I as figured.

Forceps symmetrical, as figured.

Loc.—Under stones, Edge Hill, Cairns, Queensland, 2 June 1945 (D. C. S.).

Remarks—Described from two specimens received from F./Lt. D. C. Swan The paratype is a juvenile specimen of only 2100μ in length.

This species is very different from the only other known species of *Parajapyx* from Australia (*P. swani* Wom. from South Australia) in the structure of the forceps.

Subfamily INDJAPYGINAE

Genus Indjapyx Silv. 1930

Rec. Indian Museum 1930, 32, (4), 451.

Indjapyx goodenoughensis n. sp.

Fig. 2 C-F

Description—Colour yellowish, with somite IX, X and forceps somewhat deeper yellow. Head rounded, about as wide as it is long, dorsally with 9 + 9 long and strong simple macrochaetae and others shorter and still shorter; without the fine pubescence posteriorly as in many of the hitherto described species. Antennae 44-segmented, with sensillae only on segment IV to VI, the dorsal sensillae on IV placed subposteriorly as is characteristic of the genus. Thorax dorsally with long and short setae, the macrochaetae as follows: pronotum with 6 + 6, subanteriorly 2 + 2, sublaterally 2 + 2, and subposteriorly 2 + 2; mesonotum with 5 + 5, subanteriorly 2 + 2, laterally 1 + 1, subposteriorly 2 + 2; metanotum 5 + 5, subanteriorly 2 + 2, laterally 1 + 1, subposteriorly 2 + 2; ventrally on prosternum, praesternal 4 + 4 macrochaetae, then 1 median plus 4 + 4 subanterior, within the furca 4, then 1 + 1 lateral and 3 + 3 subposterior; meso- and metasterna similar.

Abdomen similarly with long and short macrochaetae; tergites I with 1 + 1 subposterior submedian and 1 + 1 subposterior macrochaetae; II-III with 4 + 4

lateral and 1 + 1 subposterior submedian; IV-VII with 4 + 4 laterally only, VIII with 1 + 1 lateral subposterior; IX and X as figured. Sternites furnished with more macrochaetae, I-VIII with from four to two rows of long and short setae. Sternites II-VII with long conical stylets as in fig. 2 E. Subcoxal organ on sternite I displaced in mount and details not available for description. Legs with

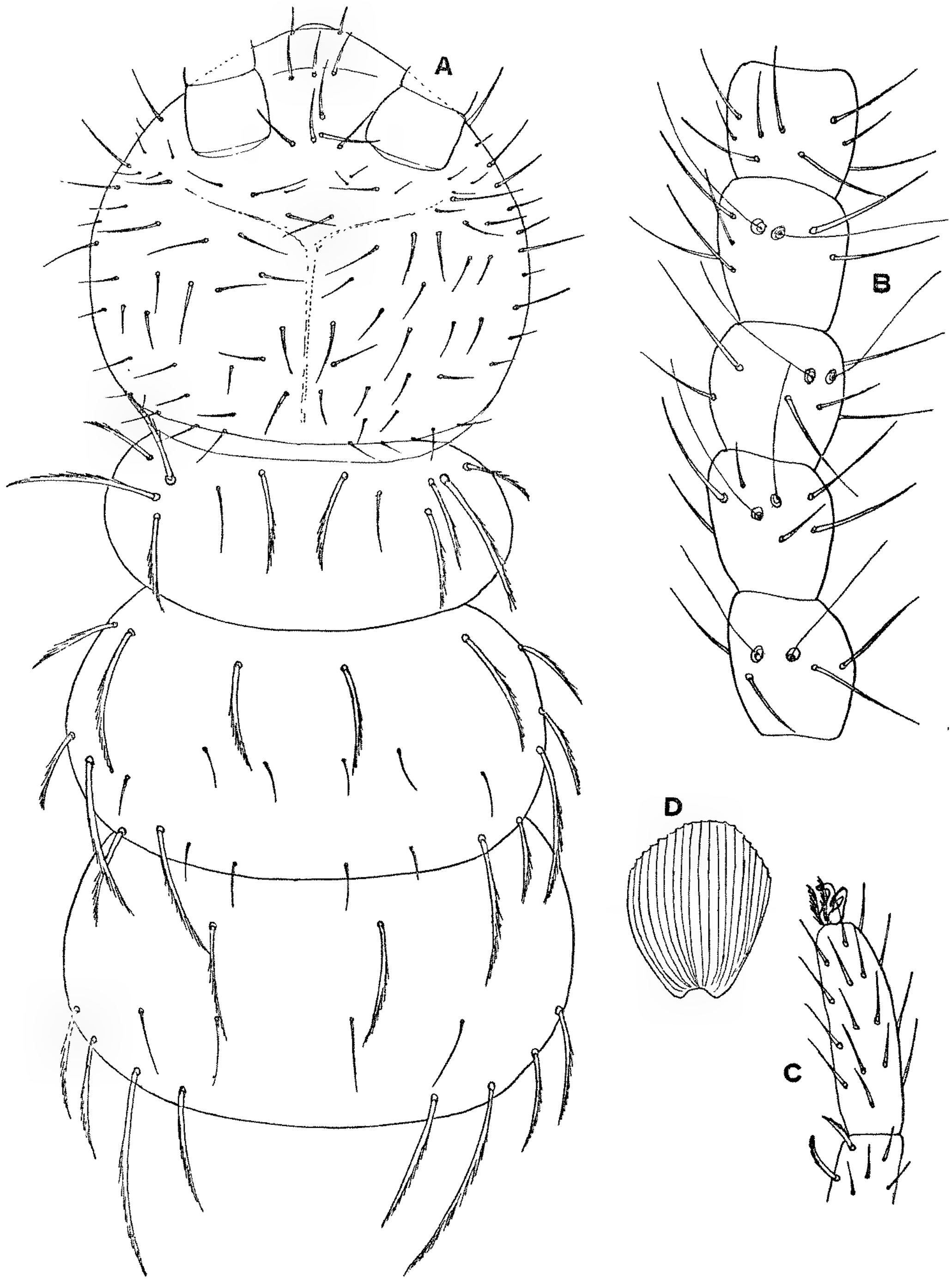


Fig. 3 *Lepidocampa weberi* Ouds.
A, head and thoracic tergites; B, antennal segments III-VII; C, tip of tibia, and tarsus of leg III; D, scale from abdominal tergites.

paired slightly unequal claws. Forceps as in figure, symmetrical. Tergites with the lateral apical angles rounded in I-VI, produced into a point in VII (*cf.* fig. 2 C).

Length 6·0 mm., antennae 3·1 mm., forceps 525μ.

Loc.—A single specimen from Goodenough Island, New Guinea, collected by F./Lt. D. C. Swan, January 1944.

Remarks—In the subposterior position of the dorsal sensilla on antennae IV, and the proportions of somites VII-IX, this species comes into Silvestri's genus *Indjapyx*. It differs from most described species and varieties in lacking the pubescence on the posterior portion of the head, and in the number of antennal segments. Also the absence of all macrochaetae except laterals on tergites IV-VIII is remarkable, although in other species they are comparatively few, and only represented by one or two pairs.

Family CAMPODEIDAE

P. 228, between line 15 and 16 insert "LEPIDOCAMPA cf. WEBERI Ouds. 1890."

Colour, creamy-white. Length 2·4 mm. Antennae ca. 20-segmented Cerci ca. 10-12 segmented. Head dorsally with long and short smooth setae, as figured. Pronotum with 1 + 1 anterior submedian macrochaetae strongly feathered, and 4 + 4 similar sublateral and subposterior macrochaetae, of which the second from the posterior angle is very long; mesonotum with 1 + 1 antero-submedian, 2 + 2 antero-lateral and sublateral, and 4 + 4 lateral and subposterior, the second from posterior the longest; metanotum with 1 + 1 antero-submedian, and 4 + 4 postero-sublateral, the second from posterior the longest. Abdominal tergite I without macrochaetae; II and III with 1 + 1 submedian, IV-VII with 3 + 3 subpostero-lateral; VIII and IX with 4 + 4 subpostero-lateral; X with many but number indeterminate. Cerci with whorls of long macrochaetae. Antennae also with whorls of macrochaetae and the usual sensillae on III-VI. Tarsi with paired claws and pulvilli.

Loc.—A single specimen from Goodenough Island, New Guinea, collected by F./Lt. D. C. Swan, January 1944.

Remarks—As the microscopic preparation is somewhat damaged it is not possible to completely describe or figure all necessary details of this specimen, but it is tentatively referred to Oudeman's species, which is known to be widely distributed in the Melanesian Region. The specimen also was preparing for an ecdysis, the setae of the next instar being visible and rendering the normal setal pattern rather difficult to make out.

LARVAL TREMATODES FROM AUSTRALIAN FRESHWATER MOLLUSCS PART X

BY T. HARVEY JOHNSTON AND ANNE C. BECKWITH (READ 9 AUGUST 1945)

Summary

Cercaria (Furcocercaria) tetradena n. sp. One of the commonest parasites of the mollusc, *Plotiopsis tatei,* from the lower River Murray, is the furcocercaria, *C. tetradena.* From 38 collections of that mollusc, in which a total of 7,592 specimens were gathered and tested in individual tubes for the presence of cercariae, 338 showed infection with the parasite, *i.e.*, approximately 4% infected. These 33 collections were made only in the warmer months, from October to May, in the years 1937-45, and snails were gathered at Tailem Bend (26 collections), Swan Reach (5 collections), Renmark (1 collection), and Morgan (1 collection). On only six out of the 33 occasions were no *C. tetradena* observed; but only one of these contained a large number of molluscs (326), the others being small collections each of less than 36 snails.

LARVAL TREMATODES FROM AUSTRALIAN FRESHWATER MOLLUSCS
PART X

By T. HARVEY JOHNSTON and ANNE C. BECKWITH

[Read 9 August 1945]

Cercaria (Furcocercaria) tetradena n. sp.
Fig. 1-5

One of the commonest parasites of the mollusc, *Plotiopsis tatei,* from the lower River Murray, is the furcocercaria, *C. tetradena.* From 38 collections of that mollusc, in which a total of 7,592 specimens were gathered and tested in individual tubes for the presence of cercariae, 338 showed infection with the parasite, *i.e.,* approximately 4% infected. These 33 collections were made only in the warmer months, from October to May, in the years 1937-45, and snails were gathered at Tailem Bend (26 collections), Swan Reach (5 collections), Renmark (1 collection), and Morgan (1 collection). On only six out of the 33 occasions were no *C. tetradena* observed; but only one of these contained a large number of molluscs (326), the others being small collections each of less than 36 snails.

In five *Plotiopsis* a double infection of *C. tetradena* and another cercaria was observed—once with the cercaria of *Echinochasmus pelecani,* once with a Xiphidiocercaria, once with a Monostome, and in the remaining two cases each with a different species of Gymnocephalan, the four latter being species not yet described.

The cercariae are emitted in greatest numbers during the morning, but in dull weather, particularly between 11 a.m. and 2 p.m. In bright weather, large numbers emerge by 9.30 a.m. They are vigorous swimmers, readily visible to the naked eye, and most of those present in a tube are in motion at any given moment. When resting, the furcae are spread each at an angle of about 90° to the tail stem, with the body hanging down. They swim tail-first, with very rapid, jerky movements. The length of life is not more than 24 hours.

For measurement, cercariae were fixed by the addition of an equal quantity of boiling 10% formalin to the water in which they were swimming. Fifteen specimens were measured and the results averaged. Measurements were made with an ocular micrometer, and using coverslip pressure only sufficient to keep the cercariae in one plane, *i.e.,* they were not distorted by pressure. Measurements are given in micra, and their range is indicated in brackets after the average. Length of body, 144 average (128-160); breadth (at widest part) 37 (32-43); length of tail stem, 159 (138-198); breadth of tail stem (widest), 26 (23-29); length of furca, 158 (133-176); breadth of furcae, 13 (11-20); length of anterior organ, 40 (30-48); breadth of anterior organ, 19 (14-25); length of ventral sucker, 18 (16-20); breadth of ventral sucker, 18 (14-20).

A live, unstained specimen appears clear and faintly yellowish. In front of the mouth are two rows of straight spines arranged alternately, four in the front and five in the second series. A variation observed, three and four in these rows respectively—may have been due to the accidental loss of two spines.

There is a small circumoral spineless area (fig. 1). Then follows a series of six to seven irregular rows surrounding the anterior half of the anterior organ. These spines are larger than those of the rest of the body, and diminish in size from before backwards. Almost the whole of the body is covered with spines

which tend to be arranged in rows, except for a small spineless area just in front of, and a long strip behind the ventral sucker. About 32 spines, arranged in two rows with the spines alternating, are borne by the ventral sucker. This arrange-

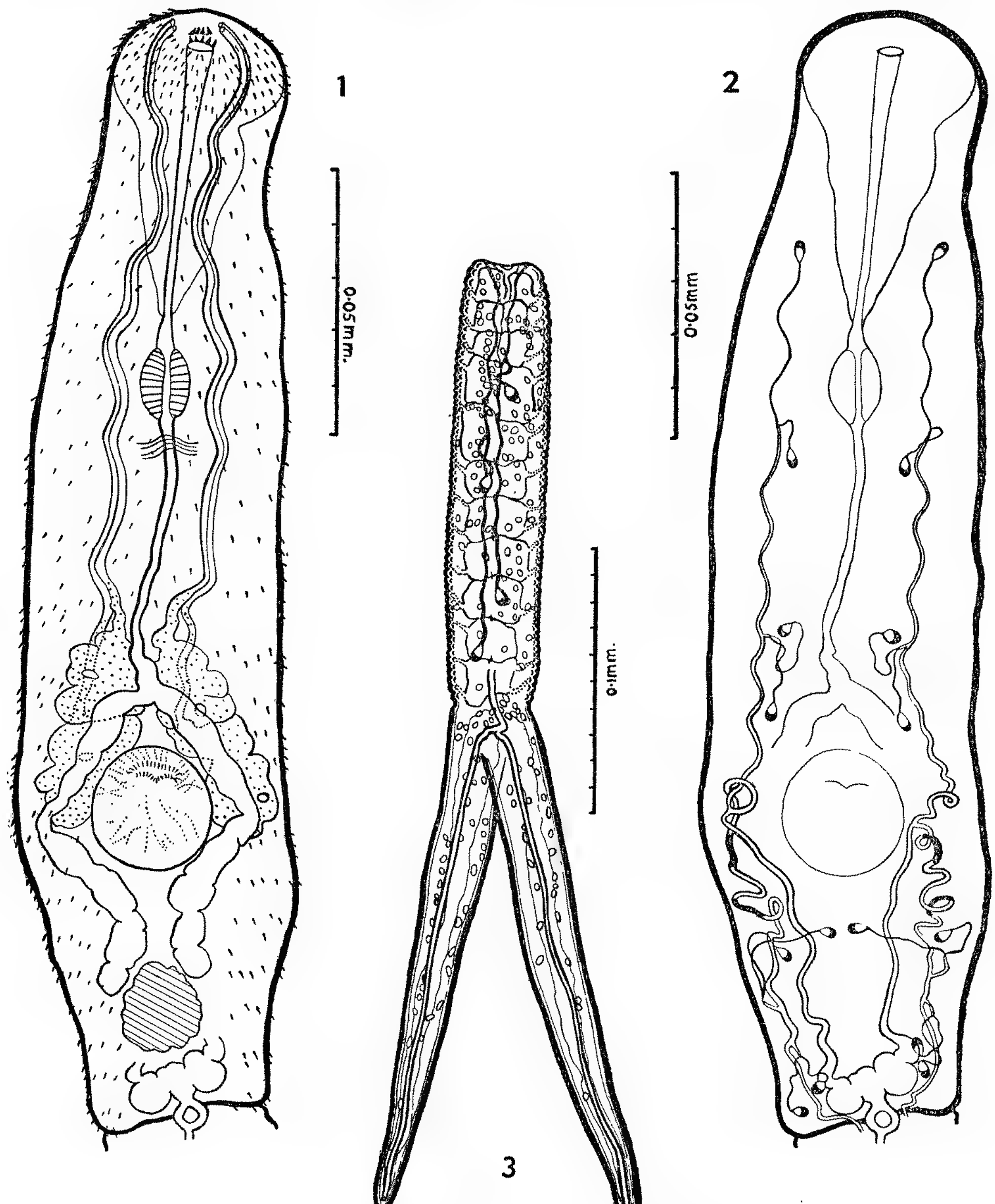


Fig. 1-3, *C. tetradena*—1, body, showing spination, digestive system, glands, suckers, nervous system, genital primordium; 2, excretory system of body; 3, tail. Outlines drawn with camera lucida, details freehand.

ment can be clearly seen only under heavy coverslip pressure. Except when greatly extended, the body has a finely corrugated appearance.

The subterminal mouth leads into a short prepharynx; then follows a muscular pharynx and a long oesophagus which bifurcates just in front of the

ventral sucker into the two broad intestinal caeca which stain with neutral red and usually have several irregular constrictions. The position of the end of these caeca posterior to the ventral sucker varies with the state of contraction, but they usually extend about half-way between the ventral sucker and the posterior end of the body.

Two pairs of prominent gland cells lie in front of, and dorsal to, the anterior half of the ventral sucker. In a greatly extended specimen, these cells are entirely anterior to the acetabulum, but in a contracted state they come to lie beside and behind it; their changing position is a very conspicuous feature of a cercaria undergoing contraction and extension. The cells appear granular and stain deeply with neutral red used intra-vitally, though their nuclei and the distal part of their ducts do not take up this stain. Other intra-vitam stains used were Orange G., which stained neither the ducts nor the glands; Nile Blue Sulphate, which stained the glands, leaving the ducts unstained; and Methylene Blue which stained neither the ducts nor the glands. Fixed specimens were stained with acetic acid alum carmine, Delafield's haematoxylin, thionin, alum carmine and Mallory's triple stain,

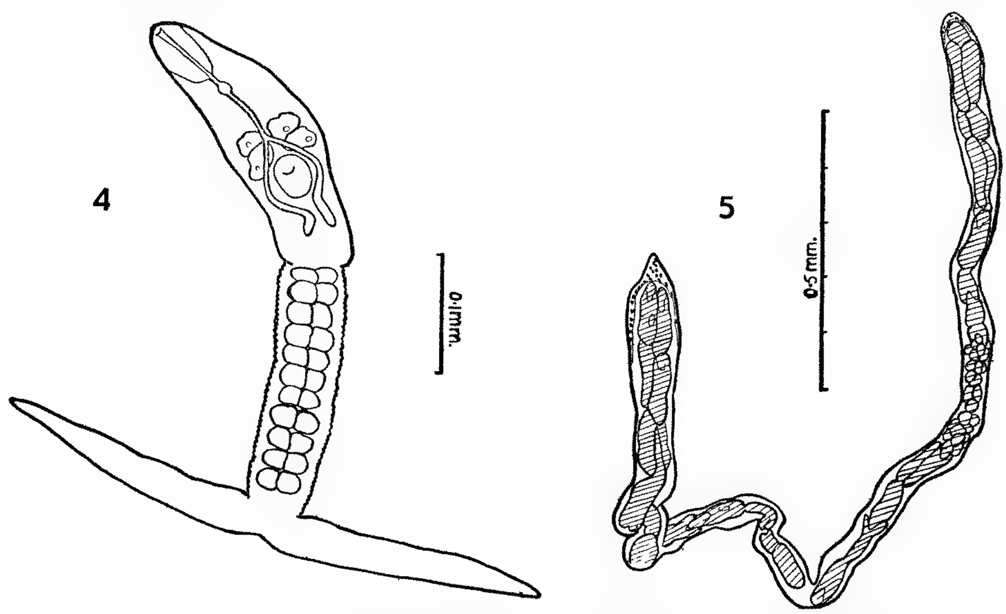


Fig. 4-5, *C. tetradena*—4, general appearance of cercaria; 5, sporocyst. Outline of 4 drawn with camera lucida, details freehand; fig. 5, drawn with camera lucida from Canada balsam mount.

but none of these, except Mallory, stained either glands or ducts, the last-named colouring the gland cells a deep maroon and the rest of the body blue.

The genital primordium or posterior cell mass stains deeply with nuclear stains, and consists of a closely packed mass of cells in which no differentiation can be observed. It lies immediately in front of the excretory bladder. The nervous system is represented by a faint bridge of tissue crossing the oesophagus immediately posterior to the pharynx.

The stem of the longifurcate tail (fig. 3) contains eleven pairs of caudal bodies, irregular in shape and connected with the walls of the tail by thin elastic strands of tissue. These bodies are capable of considerable freedom of movement within the hollow tail-system, the last pair slipping down as far as the base of the furcae. Muscle fibres are arranged chiefly longitudinally and diagonally in the tail stem.

The bladder, when fully distended, is seen to consist of a central stalk-like portion, from either side of which a larger, round part originates (fig. 2). Into the latter drains a large main collecting duct, which passes forward without forming loops to the mid-region of the ventral sucker. Here it receives from the anterior part of the body a tubule with which are connected two pairs of flame cells, the members of the anterior pair being situated just anterior to, and just posterior to, the pharynx respectively, while the more posterior pair is situated in the region of the first pair of penetration glands. The main collecting duct also receives from the posterior part of the body and from the tail-stem a tubule bearing three pairs of flame-cells, the first just in front of the ends of the caeca, the second at the level of the bladder, and the third pair from each side in the tail (fig. 3), the actual flame-cells being distributed at the levels of the fourth and ninth, and the sixth and tenth caudal bodies. The flame-cell formula is thus $2 [(2+2) + (2+2+[2])] = 20$.

From the posterior side of the central portion of the excretory bladder arises a large duct which, after first dividing at the junction of the body and tail to form an island of Cort, re-unites and passes down the centre of the tail stem between the two finer tubules which bear the flame cells. At the origin of the furcae the duct divides, a branch passing along either furca to open at the tips.

We have not been successful in our attempts to obtain the metacercaria stage. Experimental infections have been attempted with the fish, *Gambusia affinis* and *Carassius auratus*; tadpoles (*Lymnodynastes* spp.); the molluscs usually found in the vicinity of *Plotiopsis*, namely, *Amerianna* spp., *Limnaea lessoni* and *Corbiculina angasi*, as well as uninfected *Plotiopsis tatei*; also with leeches (*Glossiphonia* sp.), freshwater shrimps (*Paratya australiensis*), and larvae of dragonflies and mosquitoes.

Sporocyst Stage

Upon a dissection of a host *Plotiopsis*, sporocysts are found in great numbers, packed chiefly in the liver, but a few are to be found among the other organs. The sporocysts (fig. 5) are colourless, long, tubular, greatly coiled and twisted and difficult to unravel without breaking. The longest measured was 5 mm. in length; the breadth is variable, the ends frequently being slightly wider than the rest of the sporocyst. The walls are covered by a very thin, delicate cuticle, with sparsely distributed cells, but showing considerable thickening at either end. One end is bluntly rounded, the other usually, though not invariably, more pointed, often with a small knob at its apex. Occasionally a spherical swelling part way along the tube was observed, packed with germ-balls and more than twice the diameter of the tube. The sporocysts may contain, according to age, all stages from early cleavage and morula-like germ-balls to fully-formed cercariae, ready to emerge; or germ-balls of varied sizes only, or may be packed with cercariae all nearly mature. From sections the germ-balls appear to proliferate from the walls of the sporocyst, and may be found anywhere along its length. A birthpore could not be seen, and no movement, apart from that caused by cercariae within the lumen of the sporocyst, was observed.

Relationships

C. tetradena belongs to Miller's group of pharyngeal, longifurcate distome cercariae. Sewell (1922) divided the known forked-tailed cercariae into three main groups. *C. tetradena* falls into his Group 2, though it cannot be allocated to any of his subsidiary "Pahila," "Emarginata," "Dusra" or "Baiswan" groups. Wesenberg-Lund (1934) allotted his 18 Danish species to seven groups, which include No. 5 ("*Pro-alaria* group") with penetration glands behind the ventral sucker, and No. 6 ("*Strigea* group") with penetration glands before the ventral sucker. To this latter group our species belongs. The "*Strigea* group" cannot,

however, include only larval forms belonging to the genus *Strigea,* since Dubois (1938) stated that the cercariae of *Cotylurus* appeared to be characterised by the possession of four pre-acetabular gland cells while the presence of an excretory commissure in front of the ventral sucker constituted a second feature possessed by these larvae, the cercaria of *C. communis* (Hughes) (= *C. michiganensis* Haitsma) being an exception.

Into this *"Cotylurus"* group, as defined by Dubois, fall five cercariae rather closely resembling our species with regard to the position of the flame-cells and the two pairs of pre-acetabular gland cells, but readily distinguishable from them by the presence of the pre-acetabular excretory commissure, and differing in other minor features. These are *C. douglasi* Cort 1917; *C. Cotyluri flabelliformis* (Faust); *C. Cotyluri cornuti* (Rudolphi); and *C. helvetica* XXXIV, all with 20 flame cells as in our form, and *C. fissicauda* (La Val.) with 18 flame cells.

A further group may be distinguished from our species, though bearing some resemblance to the latter. This group possesses four pre-acetabular gland cells, but, unlike our cercaria, has a post-acetabular excretory commissure; it comprises *C. helvetica* XIV and *C. helvetica* XXXIX, each with 24 flame cells, and *C. ranae* Cort and Brackett 1938, with 20 flame cells, the arrangement of which in *C. ranae* differs fundamentally from the pattern seen in our cercaria, as there are two groups each of three flame cells high in the tail and an unpaired flame cell in the anterior part of the body.

C. tenuis Miller 1923, and *C. sudanensis 7* Archibald and Marshall 1932, possess four pre-acetabular penetration glands, but the proportions of these and of the other body organs, as well as the arrangement and number of flame cells, differ greatly from those of *C. tetradena.*

Cort and Brackett (1938) described two species of furcocercariae from *Stagnicola,* which closely resemble each other and to which they gave the names of *C. macradena* and *C. micradena.* These differ from one another mainly in the relative sizes of the penetration glands, which are unusually large in *C. macradena* and very small in *C. micradena.* The latter is also smaller in all its measurements. The other distinguishing feature is the position of the flame cells in the tail-stem; in *C. macradena* they are in a group near the junction of body and tail, while in *C. micradena* the flame-cells of the tail-stem are distributed at about regular intervals in its anterior half. Both cercariae have the posterior pair of gland cells displaced to a position dorso-posterior to the acetabulum. The gland cells of *C. tetradena* are intermediate in size between those of the two cercariae just mentioned. Apart from the position of the posterior pair of gland cells and their size, *C. micradena* and *C. tetradena* resemble each other very closely. The excretory systems are identical with respect to both formula and actual position of flame cells in relation to the other organs; the main collecting duct of both extends to the midregion of the ventral sucker; a patch of cilia is found in the posterior collecting tubule at the same level in each; the bladders are of the same shape and size. The only apparent difference is that the flame cells of the tail-stem are placed relatively further back in *C. tetradena.* Spination and digestive system are very similar. The absence of caudal bodies in *C. micradena* is a distinguishing characteristic. Measurements of *C. micradena* (body length 154μ, body breadth 40μ, tail-stem length 268μ, furca length 233μ) reveal that, though the body is of approximately equal size to that of *C. tetradena,* the tail is considerably larger.

In 1940 Olivier completed the life-cycle of *C. micradena,* proving it to be the larva of a diplostome, *Diplostomum micradenum,* which he obtained experimentally from domestic pigeons. The metacercaria was found in tadpoles. As mentioned above, we were unable to recover metacercaria of *C. tetradena* from tadpoles, using *Lymnodynastes* sp. Possibly another species of tadpole may be the natural intermediate host of our larva.

Cercaria (Furcocercaria) notopalae n. sp.

Fig. 6-16

A large furcocercaria, *Cercaria notopalae,* has been found on several occasions during examination of the mollusc, *Notopala hanleyi,* for larval trematodes. This gastropod has been collected on six separate occasions, once at Renmark (April 1939), once at Morgan (April 1942), and at Swan Reach in December 1943, December 1944, February 1945 and May 1945. The parasite has been emitted from only six out of the total number of 1,757 of these gastropods collected. approximately a 0·3% infection. It has not been found in any other species of mollusc.

Few cercariae are emitted each day, but these are conspicuous because of their large size and the clumsy movements with which they swim. As they can encyst back into the primary molluscan host, it was found advisable to remove them, upon emergence, to another vessel for study of live material. The cercariae appear during the morning in slightly increasing numbers until midday; a few are emitted luring the afternoon, but apparently none at night. They live for about 48 hours.

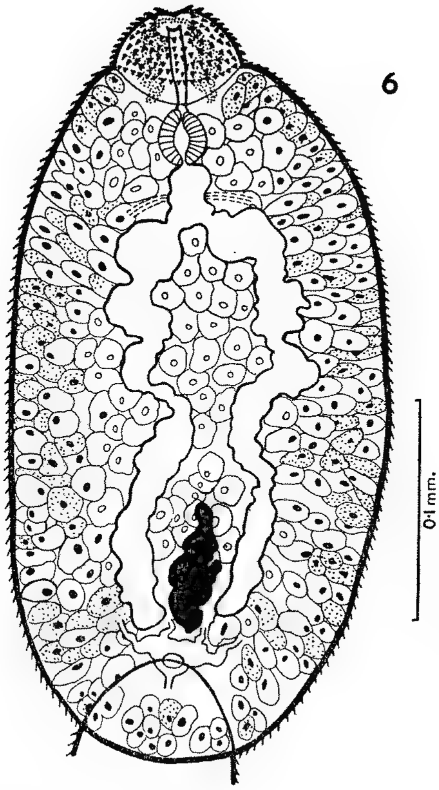
The swimming habits of *C. notopalae* are highly characteristic. The description which Komiya (1939, 360) gives of the activity of the cercaria of *Paracoenogonimus ovatus* Katsurada applies almost exactly to our species. The cercaria hangs in the water with the body at an angle of about 90° to the bent tail (fig. 13), and the furcae spread. The tail is bent at about its proximal third. In this position the cercaria very gradually sinks. As a result of contact during the resting stage, or upon shaking the water, or after sinking for some minutes undisturbed, the cercariae may swim rapidly upwards, tail-first, with awkward jerky movements, so as to maintain its floating position. It rarely moves in this rapid fashion for more than a few seconds at a time.

Cercariae were fixed by the addition of an equal quantity of boiling 10% formalin to the water in which they were swimming, and were measured from a water mount, using coverslip pressure only sufficient to keep the cercariae in one plane without distortion. The averages in micra, of ten measurements, followed by the range (in brackets) are as follows: body length, 270 (229-328); breadth at widest part, 133 (114-155); tail stem length, 423 (393-451), breadth at widest part, 41 (32-57); furca length, 294 (270-377), breadth at widest part, 42 (32-57); distance of junction of tail from posterior border of body, 32 (27-37). The tail stem is widest distally, becoming somewhat narrowed at its junction with the body.

The body of the cercaria is clear and pear-sharped. There are no special spines at the mouth. Following a circumoral spineless area (fig. 6) is a cap, over the anterior organ, of about nine rows of recurved, thorn-like spines (fig. 15), diminishing in size from before backwards. The largest are about $2 \cdot 4\mu$ long and 2μ broad at the base. The remainder of the body is beset with smaller, straight spines about $1 \cdot 6\mu$ long, not arranged in any definite order. Along each side of the tail stem, and of either furca, is a single row of similar fine, backwardly-directed spines.

The anterior organ is protrusible and can assume either of the positions shown in fig. 6 and 9. No trace of a ventral sucker was observed, even in heavily stained preparations. The ventral surface is slightly concave as described for *C. Paracoenogonimi ovati.*

Fig. 6-9, *C. notopalae*—6, body, showing spination, digestive system, glands, nervous system, genital primordium; 7, sporocyst; 8, tail; 9, excretory system of body. Fig. 6 and 8 drawn with camera lucida from preserved specimens; fig. 9 drawn with camera lucida from live mount.



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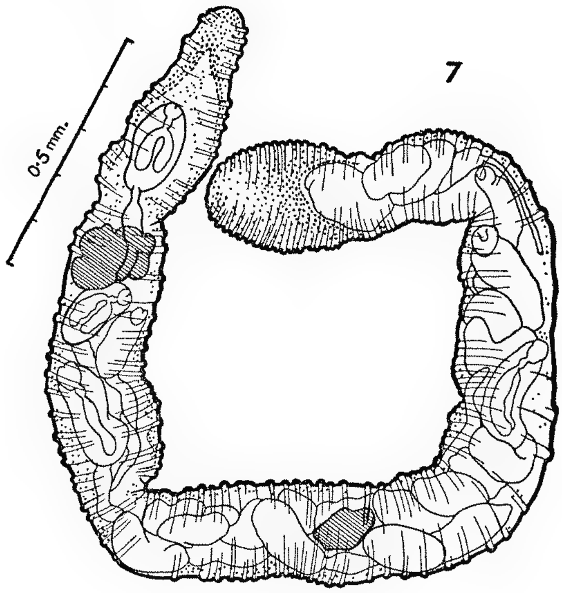

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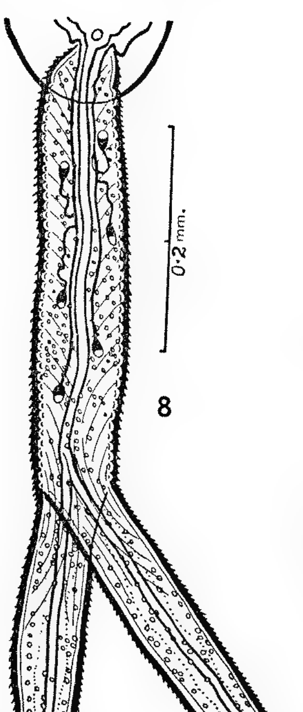

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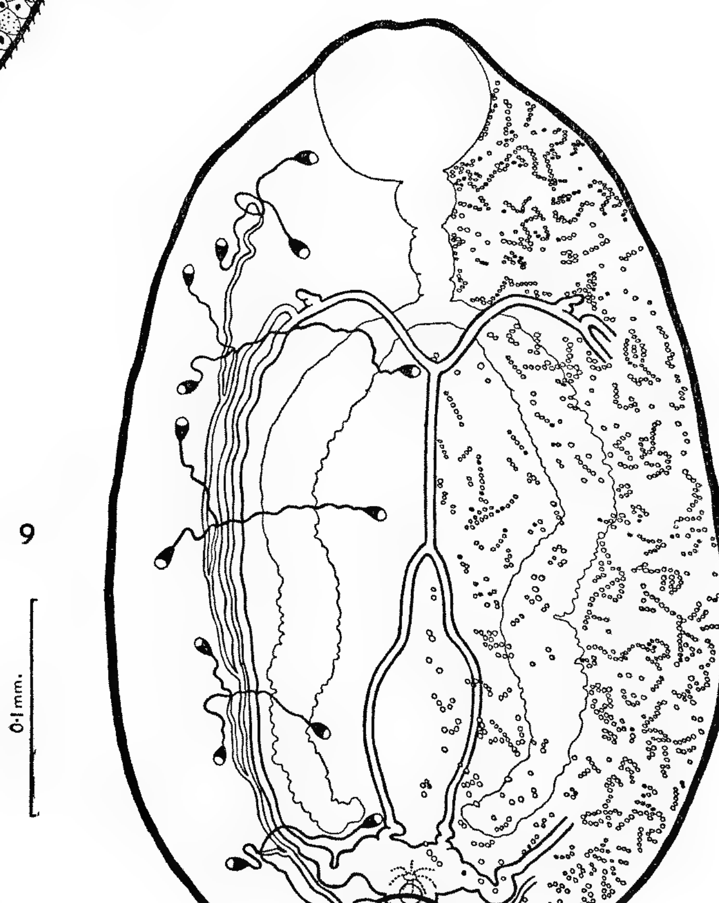

9

The subterminal mouth is followed by a short pre-pharynx, a stout muscular pharynx, a short oesophagus, which varies in diameter with the state of contraction, and two wide caeca, which stain faintly with intra-vital neutral red. In a living specimen the caeca appear quite clear, and no cell-boundaries could be distinguished as described in *C. tatei* (Johnston and Angel, 1940, 336). The caeca are typically arranged in two to three tortuous curves, and partially segmented by numerous transverse constrictions.

Most of the body is occupied by the very numerous gland cells which are inconspicuous in an unstained specimen. It was unfortunately necessary to study the glands almost entirely in preserved material. The method found most useful was to stain the preserved cercariae lightly with neutral red or with methylene blue and neutral red together, and examine in a water mount as for study of live material. This technique prevented the shrinking and brittleness incurred in using clearing agents, the worms being flat enough to render the latter unnecessary. Other stains used on preserved material were Mallory's triple stain, which stained all gland cells orange; acetic acid alum carmine, which stained their nuclei only; and Delafield's haematoxylin and carmine, each staining the nuclei darkly and some of the anterior glands faintly.

On either side of the anterior organ is a small group of gland-like organs which in live material stain very darkly with neutral red. These may be small glands, homologous with the slender head-glands which Komiya (p. 362) described as present in *C. Paracoenogonimi ovati*; or they may possibly be ducts of some of the other glands, though no connections with other cells could be traced. These glands could not be distinguished at all in preserved material.

Neutral red used as above for differentiation in preserved cercariae indicates three types of unicellular glands (fig. 6). The first group, situated on either side of and behind the oesophagus, remains completely colourless. It was these glands that stained lightly with carmine. In weak methylene blue or neutral red solution, they appear completely colourless and faintly granular with clear, unstained, refractive nuclei. A darkly staining mass on either side of the prepharynx within the anterior organ may represent the ducts of these unstained glands, or may be a further group of "head-glands," like those of *C. Paracoenogonimi ovati*. As in the latter, half of the remaining unicellular glands in *C. notopalae* stain with neutral red, while the other half remain colourless, though their nuclei become stained. These two types of cutaneous or cystogenous glands appear to have short ducts leading to the surface of the body, since in a preserved specimen numerous small round refractive drops of exudate may be sometimes found at the surface.

The posterior cell mass or genital primordium, which stains deeply with nuclear stains, has an irregular but definite shape and is situated just anterior to the excretory bladder (fig. 6). A strand of exceedingly fine fibres lying across the oesophagus apparently represents the nervous system.

The large muscular tail (fig. 8) is attached to the body not terminally but dorsally, as is usual in this type of cercaria (fig. 12). There are no caudal bodies. The furcae are finless. There are many muscular fibres arranged obliquely in the tail-stem, tending to become more longitudinal at its distal extremity. A smaller number of fine transverse fibres is also present, together with some longitudinal fibres, the latter mainly around the central canal of the tail stem. Oblique fibres are found in the furcae. Longitudinal fibres, which pass from the tail-stem to the furcae, would control the angle which the latter maintain with the former. Mallory stains the tail a deep blue, due to its muscular character. Nile-blue sulphate, which stains parenchyma blue (Talbot, 1936), colours the tail of *C. notopalae* blue when used intravitally.

From each lateral lobe of the bladder (fig. 9) arises a main collecting duct which passes anteriorly, following the curve of the corresponding caecum. At the level of the origin of the caeca, the two ducts curve back and inwards over the caeca and fuse in the midline. From the point of fusion arises a duct which, passing posteriorly, divides about half-way back to the bladder into two branches, each of which enters the bladder just anterior to the lateral lobes. At the region where the two main collecting canals begin to curve towards the midline, each gives off a short, blindly-ending protuberance which in one specimen was seen to vary as shown in fig. 16. These blindly-ending ducts and the central forked duct are equivalent to those which, in the larva of *Paracoenogonimus ovatus*, Komiya terms "reserve canals." Refractory granules, as described for *C. tatei*, were not seen in these canals.

Just posterior to the short, blind protuberance, the main collecting duct gives off a secondary duct which passes posteriorly and about half-way back to the bladder divides into two tertiary ducts; one of these passes forwards and drains three capillaries, each with a group of three flame-cells; the other passes posteriorly, draining the capillaries from two further groups, each of three flame-cells, and then passes into the tail at the side of the central canal, where it drains three further flame-cells (fig. 8-9). The excretory formula is hence $2[(3+3+3) + (3+3+[3])] = 36$.

The central canal of the tail is connected with the posterior lobe of the bladder by two branches, which surround an island of Cort; the canal bifurcates at the distal end of the tail-stem, a branch passing to either furca to open at its tip. The bladder has a dorsal excretory pore as indicated in fig. 9.

Throughout the body of the cercaria are many small round refractory bodies (fig. 9, showing those of the right-hand side) arranged in groups, clusters or singly. Though these appear to have no connection with the canals of the excretory system, they are probably rudiments of the secondary excretory system.

Using immature cercariae taken from living sporocysts, Komiya was able to record very fully the development of the excretory system in the cercaria of *P. ovatus*. Though it has not been possible to follow the development as fully in the case of *C. notopalae* because of the lack of live material, those stages observed indicate that the main tubules arise in the same way as in the larva of *P. ovatus*. An almost mature larva, taken from a sporocyst when the host mollusc had died, was studied in more detail; its excretory system is shown in fig. 10. The refractory granules are present from a very early stage.

Sporocyst

Upon dissection of a *Notopala* which had been emitting *C. notopalae*, sporocysts were found abundantly in the liver. They are clear, faintly grey, cylindrical, with round ends, much coiled and twisted. The length and breadth are variable: one long specimen, unpreserved, measured 6 mm. Sporocysts obtained from a snail which had been dead only a few hours were found to be executing slow coiling and writhing movements, very apparent under a low-power microscope. This was due to active movement on the part of the sporocyst and not to movement within the sporocyst of cercariae, which somtimes cause a similar effect. Some of the sporocysts have a banded appearance (fig. 7) like those of *C. tatei;* apparently this is due to bands of transverse muscle fibres. The sporocyst has considerable power of lengthening and shortening. All stages from germballs to mature cercariae are found within a single sporocyst. A birthpore was not seen.

Metacercaria

Cercaria notopalae has been found experimentally to encyst in the molluscs, *Limnaea lessoni*, *Amerianna pyramidata* and *Notopala hanleyi*. In every *Notopala*

dissected for sporocysts, cysts of our parasite as a natural infection have been discovered. Since *Notopala hanleyi* is usually found in deeper water along the river banks and *Amerianna* and *Limnaea* chiefly in swamps, the latter are probably rarely infected in nature. No cysts were recovered from the fish, *Gambusia affinis*, after exposure to infection with *C. notopalae*.

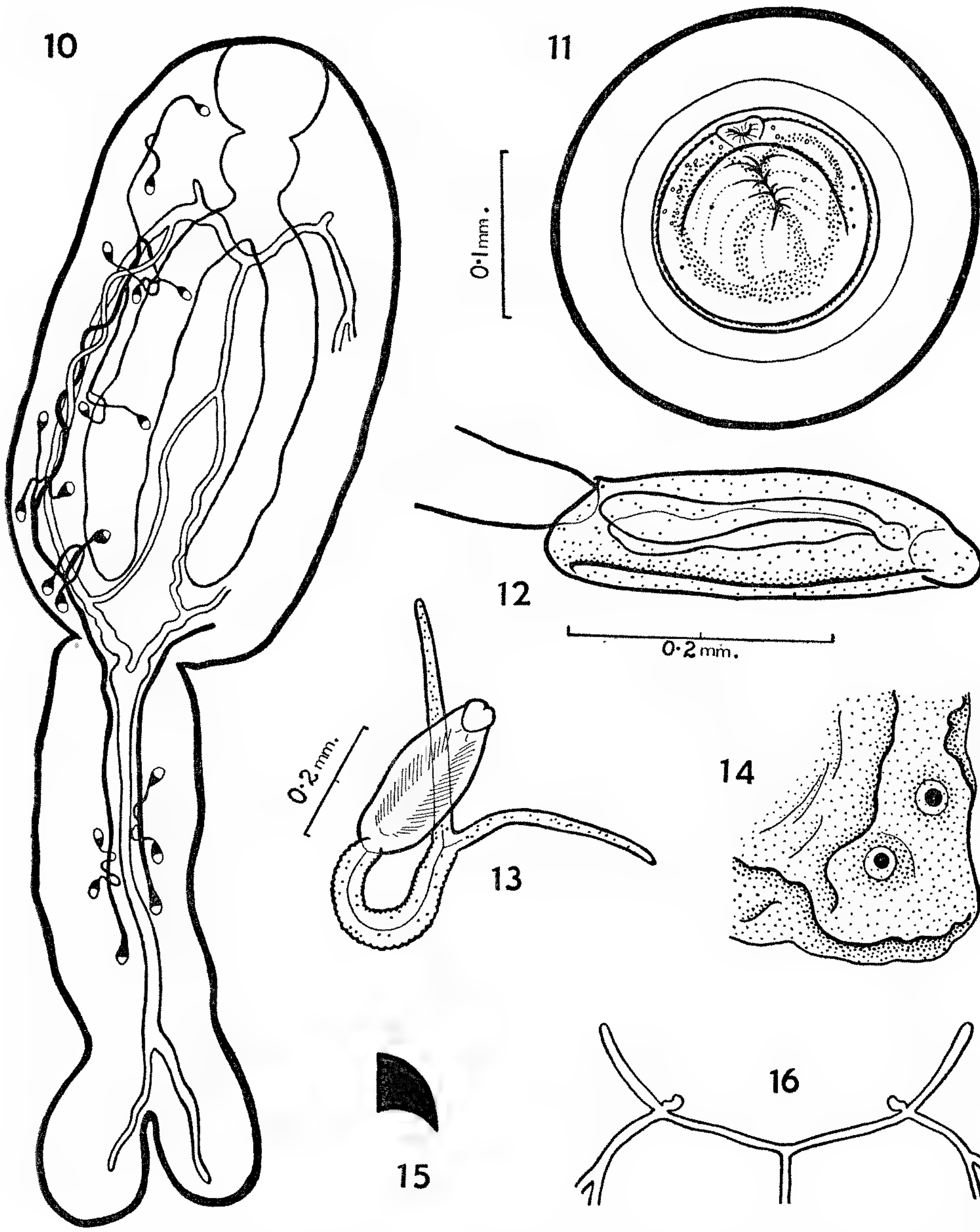

Fig. 10-16, *C. notopalae*—10, immature cercaria; 11, cyst; 12, showing dorsal attachment of tail; 13, floating position in a drop of water, without coverslip; 14, cysts *in situ*; 15, spine from anterior organ; 16, part of excretory system, showing variation. Fig. 10, 14, 15 and 16 drawn freehand from life; fig. 11-12 drawn with camera lucida from preserved material; fig. 13 drawn with camera lucida from life.

The clear spherical cysts are conspicuous in the darker surrounding tissue (fig. 14) and are found usually in the denser tissues of the molluscs, particularly the mantle. The cyst wall is very thick (fig. 11), formed of two layers, an inner denser and an outer lighter layer, similar to those described by Ciurea (1933, 156-159, fig. 14, 15, 16, 17) for *Prohemistomulum circulare* from fish, though our larva lacked the pigment so characteristic of the former. *Prohemistomulum circulare,* first recorded as the metacercaria of *Opisthorchis felineus* by Askanazy (1905), was proved to be the larva of *Paracoenogonimus ovatus* by Katsurada (1914), by the feeding of infected fish to mice, and this experiment was confirmed in 1939 by Komiya, with further details of the life-history. Szidat (1933), in describing *C. Monostomi viviparae,* which, like *C. notopalae,* encysts in the mantle of the molluscan first intermediate host, included a photograph (fig. 6) of the cysts *in situ* in the mantle, and these bear a striking resemblance to the cysts of *C. notopalae.*

The dimensions of ten preserved specimens of *C. notopalae* in micra, averaged, are: diameter of cyst (excluding cyst wall), 150 (140-162); thickness of cyst wall, 77 (63-86).

In a metacercaria only three weeks old, the holdfast is well developed and occupies a large proportion of the space. There is no sign of a ventral sucker. The anterior organ is apparent and the course of the main excretory ducts is indicated by the small granules within them. Refactory granules of larger size as described for the cercaria are present. No further details can be seen in the preserved, encysted metacercaria, which is a small round worm, no longer than the inner diameter of the cyst.

Relationships

Cercaria notopalae belongs to Group 3 in Sewell's (1922) classification of furcocercariae, though it does not resemble members of either of the subsidiary *"Vivax"* or *"Tetis"* groups which he established. The *"Vivax"* group was characterised by the presence of a rudimentary ventral sucker, furcal finfolds and 30 flame-cells, and comprised *C. vivax* Sons. 1892, *C. indica* XV and *C. indica* LVIII; while the *"Tetis"* group with neither ventral sucker nor furcal fins, and with only 14 flame-cells, included a single form, *C. indica* XXXIII. Miller (1923) divided his somewhat artificial group of pharyngeal, longifurcate, monostome cercariae into three subsidiary groups. He followed Sewell's classification for his first two—*"Vivax"* and *"Tetis"* groups—adding to the former *C. leptoderma* Faust 1922; but the third group, which he called the *"Rhabdocaeca"* group, contained three forms only very distantly related to the *"Vivax"* and *"Tetis"* groups. Szidat (1933) described three new species of monostome furcocercaria, namely, *C. balthica* and *C. curonensis* (= larva of *Cyathocotyloides curonensis*) which he allocated to Sewell's *"Tetis"* subgroup, and *C. Monostomi viviparae* (= larva of *Linstowiella vivipara*) for which he created a new subgroup, characterised by the possession of 24 flame-cells. This cercaria also lacked a ventral sucker and furcal fins, and possessed very numerous glands. To this last-named cercaria, *C. notopalae* bears a close resemblance, even though the number of flame-cells is different. Wesenberg-Lund (1934) listed three cercariae—his *"Cercaria vivax," Cercaria* sp. (which he described as closely resembling his *C. vivax,* although it possessed no furcal fins), and *Cercaria* No. 4 Petersen—which he grouped together in the *"Vivax"* group. Komiya (1937), in describing the life-cycle of *C. Paracoenogonimi ovati,* recorded the larva as a forked-tailed, monostome cercaria without comparing it with similar forms already described.

Dubois (1938) claimed that all cercariae possessing an excretory system "comprising four lateral collecting ducts: two external, joined together by an anterior commissure, and two internal, converging and fusing into a median canal which meets the commissure in its middle," were members of his superfamily

Cyathocotylides. This definition includes all cercariae placed by earlier authors in the *"Vivax," "Tetis"* and *"Vivipara"* subgroups, and also our larva, *C. notopalae.* The cercariae of Miller's *"Rhabdocaeca"* group belong, not to the Cyathocotylides but to Dubois' superfamily Strigeides.

Dubois classified the Cyathocotylid cercariae further into five groups as follows:

1 *"Vivax"* group as defined by Sewell; Dubois including in this *C. indica* XV, *C. dorsocauda* Tub. 1928, *C. vivax* Wes.-Lund. 1934, *C. indica* LVIII (although the last has no trace of a ventral sucker), as well as *C. vivax* Sons. 1892 and *Dicranocercaria utriculata* Lutz 1934, in which the number of flame-cells is unknown.

2 *"Vivipara"* group as defined by Szidat, including only *C. Monostomi viviparae.*

3 *"Tetis"* group as defined by Sewell, comprising *C. indica* XXXIII, *C. curonensis, C. balthica* and *C. Cyathocotylis gravieri* Mathias 1935 (the larva of *Cyathocotyle gravieri*).

4 *"Leptoderma"* group, containing only *C. leptoderma,* characterised by the possession of an excretory system with a formula $2 [(3+3+3) + (3+3 + [3])] = 36$, no ventral suckers, no fins, spines, only on the anterior organ. and a brevifurcate tail as defined by Miller, *i.e.,* the furcae are less than one-half the length of the tail stem.

5 *"Tauiana"* group, comprising only *C. tauiana,* with an excretory formula of $2 [2+2+2] = 12$ flame-cells, none of which are in the tail, no ventral sucker, no fins on the furcae, and apparently no histolytic glands.

C. vivax Sons. 1894 (*nec.* Sons. 1892), which is probably the larva of *Szidatia joyeuxi,* is considered by Dubois as constituting a possible sixth subgroup; the flame-cell number is at least 14, but the arrangement of those observed (Dubois' Monograph, fig. 335) differs fundamentally from all other Cyathocotylid cercariae.

Cercariae of the Cyathocotylid type not mentioned by Dubois include *Cercaria* sp. Wes.-Lund 1934 and *Cercaria* No. 4 Petersen (Wesenberg-Lund 1934, 128-133), the descriptions of which are too inadequate to make possible further comparisons; *C. gigantosoma* Faust (1926, 105-106), which its author claimed had certain affinities with the *"Vivax"* group, but which is probably a member of the Strigeides; the cercaria mentioned by Leiper and Atkinson (1915) is also a possible addition to the *"Vivax"* group; *C. tatei* Johnston and Angel 1940, which resembles members of the *"Vivax"* group except that the excretory system comprises 36 flame-cells; *C. kentuckiensis* Cable (1935) which resembles the *"Vivax"* group except that it possesses 34 flame-cells; and *C. Paracoenogonimi ovati,* which resembles the *"Vivipara"* group very closely, except that the flame-cell number of the former is 36, and of the latter 24.

Cercaria notopalae appears to have closer affinities with the *"Vivipara"* group and with *C. Paracoenogonimi ovati* than with any other group of Cyathocotylid cercariae. A classification based wholly on the number of flame-cells would relate our cercaria closely to *C. tatei* and *C. leptoderma;* but in the latter, the very short furcae, the position of the glands in the anterior third of the body only, the aspinose condition of the body, the nature of the intestinal cells, and the larger size, differentiate sharply between the two larvae; while in the case of *C. tatei,* the arrangement of the glands, the presence of a rudimentary ventral sucker and of furcal fins, and the character of the intestinal cells distinguish the two, even though they are of similar dimensions. Moreover, *C. tatei* encysts in fish, while *C. notopalae* encysts in molluscs. One point of resemblance between the two is the development of *C. tatei* in a sporocyst with bands of muscle such as are

possessed by *C. notopalae,* although in the latter the occurrence and distribution of such bands are less regular.

C. notopalae resembles *C. Paracoenogonimi ovati* in the number, distribution and nature of the gland-cells; in the character and arrangement of the spines on both body and tail; in swimming habits; in the number and arrangement of the tubules and flame-cells of the excretory system—the two are identical; in the absence of furcal fins and ventral sucker; in the position of the sporocysts in the liver of the host mollusc; and in size, *C. Paracoenogonimi ovati* being slightly larger (body length = 0·335 mm., tail stem = 0·515 mm., furca = 0·337). The first intermediate hosts are closely related molluscs—*Vivipara vivipara* for the one, *Notopala hanleyi* for the other. The larvae differ mainly in the presence of sensory filaments on the tail-stem of *C. Paracoenogonimi ovati,* and their absence from the Australian form; and in the choice of second intermediate host—molluscs for *C. notopalae,* fishes for the other species.

Our larva resembles *C. Monostomi viviparae* in the large number of glands, absence of furcal fins and ventral sucker, the very similar appearance of the cysts which are comparable in size (cyst wall of *C. Monostomi viviparae* 0·04 mm., cavity of cyst 0·19 mm.) and in the position of the sporocysts in the liver of the mollusc. Both develop in related molluscs—*Notopala* and *Vivipara vivipara* respectively. The two larvae are of almost identical size, measurements of *C. Monostomi viviparae* indicating that its body length is 0·22 mm.; tail stem 0·42 mm., furca 0·30 mm. The latter cercaria, however, possess sensory filaments on the tail-stem and apparently no spines, and has a smaller number of flame-cells, which are arranged, nevertheless, in the same fundamental pattern, with five groups in the body, the formula being probably $[2(2+2+2+2+1+[3]))] = 24$. The most striking resemblance between the two forms is that both encyst back into the molluscan host, the cysts in each case being found in the mantle. No other reference to Cyathocotylid cercariae encysting in molluscs has been noticed by us, apart from the discovery by Faust 1921, of "Tetracotyliform larvae" in the testes of *Vivipara lapillorum,* which, when fed to ducks, developed into *Cyathocotyle orientalis,* and a suggestion made by Faust (1930) concerning *C. tauiana, viz.,* "no histolytic glands are present. It seems likely, therefore, that the larva metamorphoses into the next stage within the same molluscan host." However, Faust and Tang (1938) stated that it seemed probable that all Cyathocotylids had a similar life-cycle; there was an anacetabular, forked-tailed cercariae which developed in fresh-water molluscs, and on emergence invaded the tissues of fresh-water fish where they underwent metamorphosis into a *Prohemistomum* type of metacercaria; when fishes infected with these metacercariae were ingested by reptiles, birds or mammals, they developed into adult worms in these, their definite hosts. This statement holds for all Cyathocotylids whose life-history is known, except *Linstowiella vivipara.* In the latter, the mollusc *Vivipara vivipara,* is the second, as well as the first intermediate host, and the adult is a parasite in the intestine of *Sterna paradisea.*

Dubois considers that all of the subgroups *"Vivax"* and *"Vivipara"* are larvae of his subfamily Prohemistominae, since all adults developed from these larvae up to the time of his monograph belonged to genera within this group. Similarly, cercariae of the *"Tetis"* group are probably larvae of Dubois' subfamily Cyathocotylinae. The adult of *C. notopalae* will presumably be a member of the Prohemistominae, closely related to the genera *Linstowiella* and *Paracoenogonimus,* parasitic in a mollusc-eating bird, *e.g.,* one of the native ducks.

Summary

1 *Cercaria (Furcocercaria) tetradena,* a new species of Strigeid larva from *Plotiopsis tatei,* from the River Murray, is a longifurcate, distome cercaria,

possessing four pre-acetabular penetration glands, but without an excretory commissure. The adult may belong to the genera *Diplostomum, Cotylurus* or *Strigea.*

2 *Cercaria* (*Furcocercaria*) *notopalae,* a new species of Cyathocotylid larva from *Notopala hanleyi,* also from the River Murray, is a large, anacetabular furcocercaria which encysts in molluscs and is closely related to the larvae of the genera *Linstowiella* and *Paracoenogonimus.*

Our thanks are due to Messrs. G. G., Fred and Bryce Jaensch, and L. Ellis, of Tailem Bend, Murray River, for assistance in gathering *Plotiopsis tatei;* and to our colleagues, particularly Miss P. M. Mawson, for helping collect *Notopala hanleyi,* which is not found at Tailem Bend. The work was carried out under the terms of the Commonwealth Research Grant to the University of Adelaide.

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CAPILLARIID NEMATODES FROM SOUTH AUSTRALIAN FISH AND BIRDS

BY T. HARVEY JOHNSTON AND PATRICIA M. MAWSON (READ 9 AUGUST 1945)

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The genus *Capillaria* is relatively poor in characters of taxonomic value, and though numerous species have been named, the descriptions of many are insufficient. In the present paper the main taxonomic features considered are:- the ratio between the regions of the body, and the characters of the spicule, spicule sheath, bursa, vulva and eggs. Measurements given for eggs have been based on those nearest the vulva, since those further removed may show considerable variation in size and form.

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Many helpful figures and descriptions were found in the papers published by Freitas and Lent (1935) and Heinze 1933) on species from fish; and Cram (1936), as well as Freitas and Almeida (1935) on species from birds. Types are being deposited in the South Australian Museum.

We desire to acknowledge our indebtedness to Messrs. H. M. Hale, K. Sheard, H. M. Cooper, S. Hurcombe, and E. J. Hanka for forwarding viscera from fish; Messrs. G. G., F., and B. Jaensch and L. Ellis for generous assistance for many years in obtaining material from the Tailem Bend region of the River Murray; and to the Commonwealth Research Grant to the University of Adelaide.

HOST-PARASITE LIST

FISH

CALLIONYMUS CALAUROPOMUS Richardson—St. Vincent Gulf, *Capillaria cooperi* n. sp.

LATRIDOPSIS FORSTERI Castln.—Kangaroo Island, *Capillaria latridopsis,* n. sp.

CANTHERINES HIPPOCREPIS—Glenelg, *Capillaria cooperi* n. sp.

APTYCHOTREMA BANKSII Mull, and Henle (*Rhinobatus phillipi* of Waite's Handbook of the Fishes of South Australia)—Rapid Bay, *Capillaria rhinobati* n. sp.

BIRDS (all from the Tailem Bend district, Murray River)

PHALACROCORAX CARBO Linn.—*Capillaria jaenschi* n. sp.

PHALACROCORAX SULCIROSTRIS Brandt—*Capillaria jaenschi* n. sp.

PHALACROCORAX MELANOLEUCAS Vieill.—*Capillaria jaenschi* n. sp.

PHALACROCORAX FUSCESCENS Vieill.—*Capillaria jaenschi* n. sp.

PELECANUS CONSPICILLATUS Temm.—*Capillaria jaenschi* n. sp.

LARUS NOVAEHOLLANDIAE Stephens—*Capillaria jaenschi* n. sp.

CHLIDONIAS LEUCOPAREIA Temm.—*Capillaria jaenschi* n. sp.

CHENOPSIS ATRATA Lath.—*Capillaria ellisi* n. sp.

POMATOSTOMUS SUPERCILIOSUS Vig. and Horsf.—*Capillaria pomatostomi* n. sp.

GRALLINA CYANOLEUCA Lath.—*Capillaria grallinae* n. sp.

Capillaria rhinobati n. sp.

Fig. 1-3

From *Aptychotrema banksii,* from Rapid Bay, collected by H. M. Cooper. The material consists of one broken male worm, a whole female, and several parts of females. The body bears ventrally a bacillary band which extends throughout the length of the body.

The single complete female specimen is 20·4 mm. in length, with its oesophageal region 6·5 mm. long, or one-third of the body length. The posterior end terminates abruptly, and the anus is almost terminal. The body width at the anterior end is 7μ; at the base of the oesophagus 52μ; and at the widest part of the worm 80μ.

The vulva is just posterior to the oesophagus, and its position is made conspicuous by a flap formed by the intrusion of the end of the vagina. Eggs are

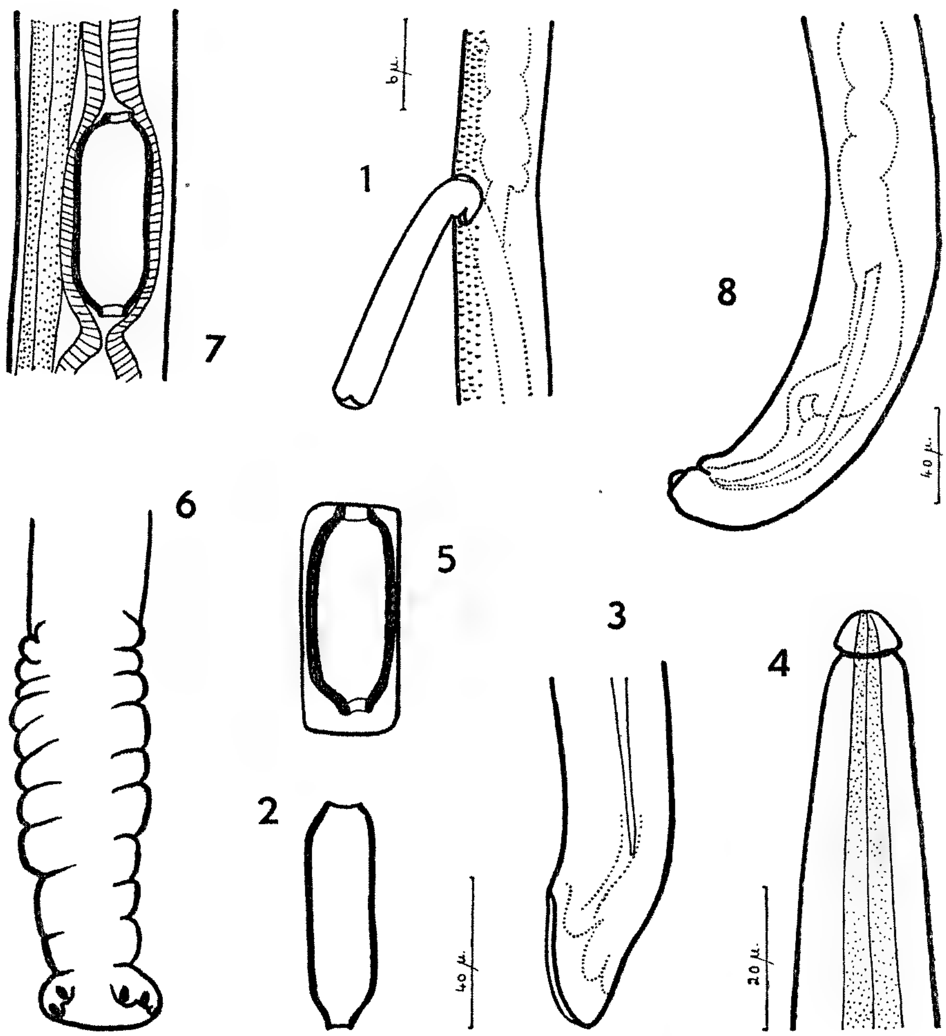

Fig. 1-8
Fig. 1-3—*Capillaria rhinobati:* 1, vulvar region; 2, egg; 3, male tail. Fig. 4-6 —*Capillaria latridopsis:* 4, anterior end of female; 5, egg; 6, male tail. Fig. 7-8—*Capillaria cooperi:* 7, vulvar region; 8, male tail. Fig. 2, 3, 5 and 7 to same scale; fig. 6 and 8 to same scale.

present in larger numbers than is usual in members of this genus; they are thin-shelled and measure 19μ by 63μ.

The male specimen present is incomplete, consisting of an intestinal region 13·7 mm. long with a maximum width of 60μ and part of the oesophageal region (2·4 mm. in length) with a width of 54μ at the base of the oesophagus. The

spicule is ·16 mm. long. A small bursa, containing five lobes of hypodermis, is present. The spicule sheath is not extruded, and spines are not discernible.

The appearance of the egg of this species is somewhat like that of *C. helenae* Layman 1930, and *C. tomentosa* (Dujardin). The species differs from the latter in having a smooth egg-shell, and from the former in total length and in the length of the spicules.

Capillaria latridopsis n. sp.

Fig. 4-6

From *Latridopsis forsteri*, Kangaroo Island, colllected by S. Hurcombe. The material consists of a male and a female, both incomplete. The male piece, whose head is missing, measures 6·7 mm. long, of which the intestinal region occupies 2·8 mm. The female piece is 10·2 mm. in length and its oesophageal region 9·4 mm. The species is obviously one in which the length of the anterior end greatly exceeds that of the posterior. The configuration of the anterior end of the female is shown in fig. 4.

The body widths at different levels are, for males and females respectively, 55μ and 68μ at the posterior end of the oesophagus, and 63μ and 81μ at widest part of the worm. The width of the head in the female is 8μ.

The posterior end of the male is widened into two narrow lateral flanges which appear like caudal alae, but which are not continuous with the small bursa. The spicule is ·3 mm. long. No spinous sheath was observed.

The position of the vulva in the female is marked by a flap of cuticle. The eggs are 25μ by 58μ, and each is enclosed in a capsule. The measurements agree with those of *C. brevispiculata* as given by Freitas and Lent 1935, but it differs in egg-shell. The species differs from *C. helenae* Layman in the ratio of the body parts.

Capillaria cooperi n. sp.

Fig. 7-8

From *Callionymus calauropomus* (St. Vincent Gulf; South Australian Museum material), type host, and *Cantherines hippocrepis*, from Glenelg, collected by H. M. Cooper. The material comprises numerous males and two females of a short stout species of *Capillaria*. The males are 4-5 mm. long, the females 5·4-7·9 mm. long. The widths at various levels of the body are, for male and female respectively, 7μ and 10μ at the head, 45μ and 54μ at the base of the oesophagus, and 54μ and 63μ at the widest part of the intestinal region. The ratio of the length of oesophageal region to the total body length is 4:7 in the male, 5:7 in the female.

No bursa is present in the male, the cloaca opening ventrally near the tip of the tail. The spicule measures ·12 mm. in length.

The vulva is simple, situated just posterior to the oesophagus. The eggs are 21μ by 54μ, their shells being very finely pitted.

The relation of the body parts agrees with *C. pterophylli* Heinze 1933, but the worm is shorter and stouter, and the shape of the egg is different.

Capillaria jaenschi n. sp.

Fig. 11-13

From *Phalacrocorax sulcirostris* (type host), *P. fuscescens*. *P. carbo*, *P. melanoleucas*, *Pelecanus conspicillatus*, *Larus novaehollandiae* and *Chlidonias leucopareia*, all from Tailem Bend. *Capillaria* sp. from *Phalacrocorax fuscescens*, Hobart, recorded by us in the B.A.N.Z.A.R.E. Report (1945), belongs to this species.

The worms are long slender Capillariids, recognisable by the structure of the egg and by the form of the male tail. The body bears two bacillary bands throughout its length.

Females 7·1-27·4 mm. long; the ratio of the oesophageal to the intestinal region, 1 : 1·1-1·3. The breadth of the body measured across the head is 7μ, at the base of the oesophagus 37-41μ, and at widest part 45-90μ. The cuticle around the vulva projects as a tubular flap. The eggs, 18-20μ by 48-50μ, have coarsely pitted shells and prominent polar capsules.

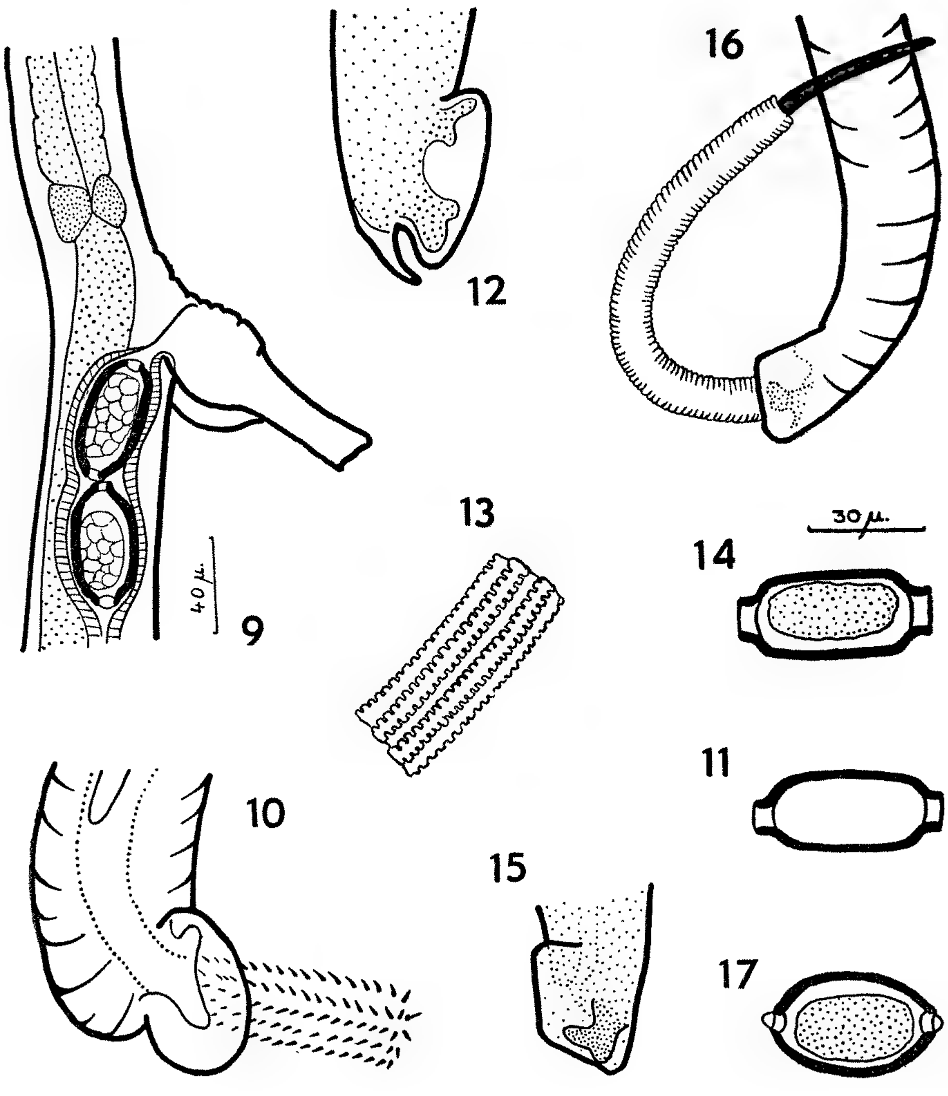

Fig. 9-17

Fig. 9-10—*Capillaria ellisi:* 9, vulvar region; 10, male tail. Fig. 11-13—*Capillaria jaenschi:* 11, egg; 12, male tail; 13, spicule sheath. Fig. 14-16—*Capillaria grallinae;* 14, egg; 15, bursa; 16, male tail. Fig. 17—*Capillaria pomatostomi,* egg. Fig. 9 and 16 to same scale; all other figures to same scale.

The male, of which only one complete specimen is available, is 9·9 mm. in length, with a ratio of intestinal and oesophageal region 1 : 1·2. The breadth of the body across the head is 6μ, at the base of the oesophagus 36μ, and at the widest part 45μ. The spicule is ·7 mm. long; the sheath extruded in one specimen bears

six longitudinal ridges with convoluted edges. The bursa consists of a dorsal and two lateral lobes, quite distinct from one another; the dorsal being narrow and in lateral view appearing as a stout backwardly-directed hook.

The species is distinguishable from the widely distributed bird parasite *C. contorta* (Creplin) by the ratio of the body parts. It is distinguished from *C. laricola* Wassilkova by the ratio of the body parts in the female, as well as by the absence of spines on the spicule sheath in the male and by the smaller size of the eggs. *Capillaria* spp., hitherto recorded from *Phalacrocorax* spp., are *C. carbonis* (Rud.) (Europe), of which no description is given; *C. appendiculata* Freitas (Brazil), from which the present species differs in spicule length and egg size; and *C. spiculata* Freitas (Brazil), from which it differs in the shape of the egg and the bursa.

Capillaria ellisi n. sp.

Fig. 9-10

From the black swan, *Chenopsis atrata,* Tailem Bend.

The material consists of one female and one male, as well as several broken pieces of worms. The complete female is 15·9 mm. long, the ratio of the oesophageal to the intestinal region being 1:1. The body width at its widest part is 63μ, at the base of the oesophagus 40μ, and at the head 5μ.

The cuticle of the anterior vulvar lip projects as a flap. The eggs are smooth-shelled and measure 37μ by 51μ.

The male is 9·2 mm. long, the ratio of the oesophageal to the intestinal region being 1:1·4. The body width at the head is 5μ, at the base of oesophagus 34μ, and at the widest part of the worm 36μ. The spicule is 1·4 mm. long. A very spinose sheath is present (fig. 10). The cuticle on either side of the cloaca projects as two bursal flaps, each supporting a bilobed portion of the hypodermis.

The form of the spicule sheath of this species is very like that of *C. contorta* and *C. triloba,* but the species differ markedly in the ratios of the anterior and posterior body parts.

The only recorded species of *Capillaria* from a swan is *C. droummondi* Trav. 1915, a description of which is not available to us. It differs from *C. anatis* (Schrank) in the absence of a bacillary band.

Capillaria pomatostomi n. sp.

Fig. 17

From *Pomatostomus superciliosus,* from Elwomple, near Tailem Bend. Only female specimens are represented. They are 14·4-15·1 mm. in length, the ratio of the anterior to the posterior parts of the body being 1:1·5-1·6. The width at the head is 7μ, at the base of the oesophagus 45μ, and at their widest part 68μ. Bacillary bands were not observed. A small cuticular flap overhangs the anterior lip of the vulva. The eggs are smooth-shelled, more ovoid in form than most Capillariid eggs, and measure 28μ by 43-45μ.

Capillaria grallinae n. sp.

Fig. 14-16

From the peewhit, or "Murray Magpie," *Grallina cyanoleuca.* Numerous specimens were obtained at various times from this host species, all from Tailem Bend. The oesophageal region tapers markedly towards the head. A single wide bacillary band is present.

The female measures 10·4-16·6 mm. in length, the ratio of the anterior to the posterior body parts being 1:1·8 (1:1·3 in one specimen). The body width at the head is 9μ, at the base of the oesophagus 46-63μ, and the widest part 57-72μ.

The vulva is inconspicuous. The egg-shell is spiny and measures 20-21μ by 50-52μ.

The male measures 11-11·5 mm. in length, the ratio of anterior to posterior body parts being 1 : 1·4. The body width at the head is 7μ, at the base of the oesophagus 36-39μ, and at the widest part 54μ. The spicule is well chitinised and measures ·9-1 mm. The spicule sheath is very strongly annulated.

The species is closest to *C. venteli* Freitas and Almeida, *C. graucalina* J. & M. and *C. emberizae* Yamaguti. The measurements agree with those given by Yamaguti for *C. emberizae;* the eggs of the latter species are described as "lemon-shaped," and as no figure is given, nor any mention of the texture of the shell, comparison is difficult; the very wide variation in egg-size mentioned by Yamaguti suggests that unripe eggs were included in his measurements. In view of this uncertainty regarding the size and shape of the eggs, and of the wide difference in locality and host, we consider it wiser to name our species as new.

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SOUTHERN AUSTRALIAN GASTROPODA PART II DOLIACEA

BY BERNARD C. COTTON (READ 13 SEPTEMBER 1945)

Summary

In this paper are given notes, records and descriptions of new species of Mollusca belonging to the superfamily Doliacea.

For many years the large collection of Australian Gastropoda in the South Australian Museum has been undergoing the process of being arranged in biological order. Good series from numerous localities now enable notes to be readily made on new species, variations, range and exact localities. In past lists the records are frequently given or implied as merely "South Australia", which covers a very big portion of the Flindersian Region.

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The following abbreviations are used in the tabular lists of Australian species:—N.A., North Australia, the North Coast of Australia and the Islands between Queensland and North-Western Australia; N.Q., North Queensland; S.Q., South Queensland; N. N.S.W., North New South Wales; S. N.S.W., South New South Wales; E. Vict., East Victoria; W. Vict., West Victoria; E. S.A., East South Australia; W. S.A., West South Australia; S. W.A., South Western Australia; N. W.A., North Western Australia; E. Tas., East Tasmania; S. Tas., South Tasmania; W. Tas., West Tasmania; N. Tas., North Tasmania; S. Pac., South Pacific; Ind. Oc., Indian Ocean.

Depths are indicated in the tables as "S" for shallow water or littoral species, "dredged" where they are from uncertain or unknown depths, and where the depths are known numbers are given representing fathoms. An asterisk indicates that the species in the genotype of the genus listed. "T" indicates "type locality."

Family CASSIDIDAE

The species form a remarkable assemblage of shallow, deeper water and varied geographical forms showing sometimes definite and at other times obscure diagnostic differences.

Phalium bandatum (Perry 1811)

Cassidea bandata Perry 1811, Conch., pl. xxxiv, fig. 2.

Fig. 1 A

Loc.—East Indies (type). Queensland: Harvey Bay; Bundaberg; Cooktown. New South Wales: Byron Bay. Western Australia: Carnarvon. North Australia: Groote Eylandt; Connexion Island.

Remarks—A single specimen of this species, of which *coronulata* Sowerby 1825 is a synonym, from Carnarvon, is very heavily built and measures 112 mm. in height.

Xenogalea denda Cotton 1945

Xenogalea denda Cotton 1945, Trans. Roy. Soc. S. Aust., 69, (1), 169.

Remarks—A figure of this recently described species is given here. Iredale 1927, Rec. Aust. Mus., 15, 342, when discussing *pyrum* and *stadialis* states "Still another shell from Tasmania, apparently a beach specimen, is superficially a large, smooth, unicolour *stadialis*, though just as certainly a *pyrum* form." This

may be *denda*, but I have not seen such a specimen in the May Collection material so far examined. From the type locality, 100 fms., Great Australian Bight, are two micromorphs, the largest 39 mm. in height, and there are no intermediates connecting with *denda*. Micromorphs of *stadialis* Hedley are also known from 25-50 fms. from the Continental Shelf of New South Wales.

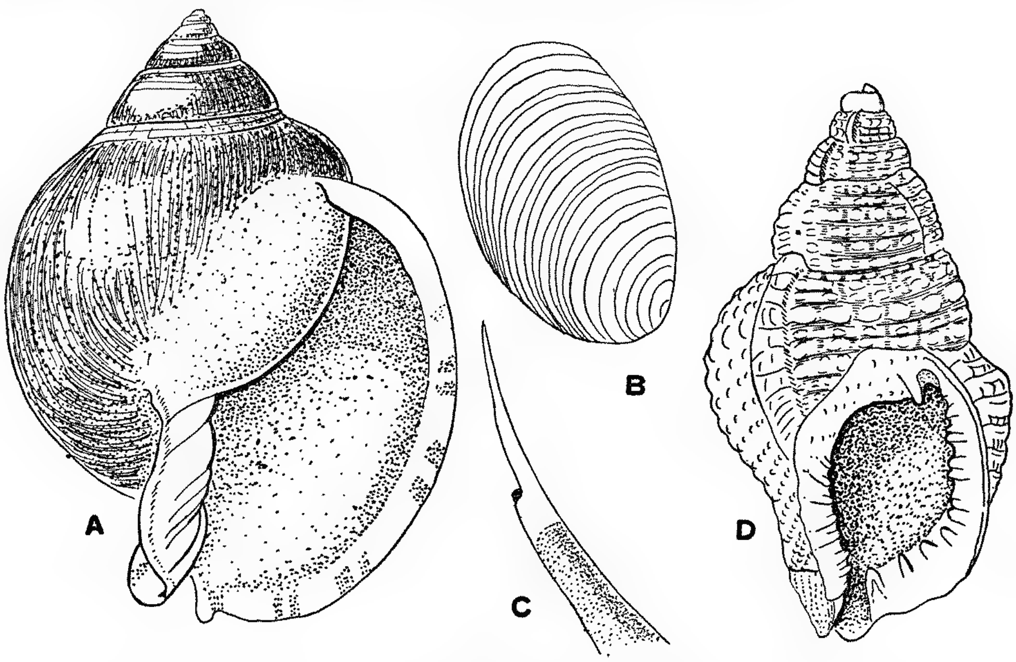

Fig. 1
A—*Xenogalea denda* n. sp., shell. B-C—*Gondwanula bassi* Angas: B, operculum; C, tentacle. D—*Negyrina delecta* n. sp., shell

Australian Species of CASSIDIDAE are here listed

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W.	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas	N. Tas.	S. Pac.	Ind. Oc.
Cassis Scopoli 1777—																		
*cornuta** Linné 1758	S	x	x															T
Nannocassis Iredale 1927—																		
*nana** Tenison Woods 1879	S			T	x													
torva Iredale 1927	S			T														
Hypocassis Iredale 1927—																		
*"decresensis"** Hedley 1923	S								T	x								
fimbriata Quoy & Gaim. 1833	S										T							
bicarinata Jones 1839	S							x	T	x	x							
Cypraecassis Stutchburyi 1837																		
*rufa** Linné 1758	S	x	x									x					x	T
Phalium Link 1807—																		
*glaucum** Linné 1758	S	x	x									x					x	T
areola Linné 1758	S		x	x	x							x					x	T
bandatum Perry 1811	S		x	x	x							x					x	T
agnitum Iredale 1927	S										T	x						
Xenophalium Iredale 1927—																		
*hedleyi** Iredale 1927	70					T												

Australian CASSIDIDAE (continued)

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W.	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas.	N. Tas.	S. Pac.	Ind. Oc.
Semicassis Mörch 1852—																		
diuturna Iredale 1927	S	x	x	x	T													
Casmaria H. & A. Adams 1853																		
*ponderosa** Gmelin 1791 ..	S			x	x												x	T
erinaceus Linné 1758	S	x	x															T
vibex Linné 1758	S	x	x														x	T
Xenogalea Iredale 1927—																		
*pyrum** Lamarck 1822	S					x	x	x					x	T				
stadialis Hedley 1914	50-100					x	T									x		
denda Cotton 1945	100-250										T							
thomsoni Brazier 1875	45-100					T												
palinodia Iredale 1931	drdgd.				x	T												
nashi Iredale 1931	drdgd.					T												
sophia Brazier 1872	S			x	x	T												
nivea Brazier 1872	S								x						T			
mawsoni Cotton 1945	120							x			T							
paucirugis Menke 1843 ..	S								x	x	T							
lucrativa Iredale 1927	S	x	T															
labiata Perry 1811	S			x	x	T												
inseparata Iredale 1927 ..	S			x	x	T												
angasi Iredale 1927	S			T	x													
spectabilis Iredale 1929 ..	50-60					T												
Antephalium Iredale 1927—																		
*semigranosa** Lamarck 1822	S						x	x	x	x	x		x	T	x	x		
adcocki Sowerby 1896	S							x	T	x	x							
sinuosum Verco 1904	15-20							x	T									
angustatum Cott. & Godf. 1931	20								T									

Family CYMATIIDAE

CYMATILESTA BARTHELEMYI (Bernardi 1857)

Triton barthelemyi Bernardi 1857, Journ. de Conch., 2, 54, pl. i, fig. 1.

Loc.—Victoria (type). South Australia: Beachport. Tasmania: Frederick Henry Bay.

Remarks—The species enters the South-East of South Australia, but I have not taken it elsewhere in that State or Western Australia. Verco 1895, Trans. Roy. Soc. S. Aust., 102, recorded *spengleri* from Middleton and Port Lincoln on the authority of Adcock and Matthews, but these shells may have been *waterhousei.* The only specimen I can find from the Matthews collection and labelled "Middleton" is certainly *waterhousei.* The South Australian and Tasmanian shells are much more obese than the typical *spengleri* of New South Wales. The Tasmanian shells grow to a large size and have very wide varices, remarkably expanding the outer lip. Three examples of this species measure: Height 140 mm., width 90 mm., Port Albert, Victoria; height 133 mm., width 77 mm., Beachport, South Australia; height 170 mm., width 100 mm., Frederick Henry Bay, Tasmania. In comparison a shell from Port Jackson, *Cymatilesta spengleri,* measures 157 mm. x 79 mm. and is comparatively longer in the spire. Queensland shells are similar in ratio of height to width. I have not seen deep water forms of *barthelemyi* so far.

CYMATILESTA WATERHOUSEI (Adams and Angas 1864)

Triton waterhousei Adams and Angas 1864, Proc. Zool., 35.

Loc.—South Australia: Port Lincoln (type), Kangaroo Island, Encounter Bay, Gulf St. Vincent, Spencer Gulf, Pondolowie Bay, Beachport, Point Sinclair; dredged, Eastern Cove, 14 and 19½ fms.; Backstairs Passage, 16½ and 20 fms.; Royston Head, 22 fms.; Port Lincoln, 9 fms.; Newland Head, 20 fms.; Thorny Passage, 25 fms.; Beachport, 40 fms.; St. Francis Island, 15 to 20 fms. Alive down to 25 fms. Western Australia: Esperance, Albany, Ellenbrook, Bunbury.

Remarks—The species is thinner and lighter than *spengleri* and has a broad flattened varix forming the outer lip on which the external ribbing is produced, not the internal sculpture as in *spengleri,* and also the spiral lirae are double. The periostracum has a series of longitudinal fringes with numerous projecting bristles, sometimes up to 5 mm. in length, and the interspaces are covered with a system of delicate periostracum lamellae forming a right-angled criss-cross pattern. Sizes for the shells are as follows:

Height 120 mm., width 65 mm.	Port Lincoln, South Australia.
Height 94 mm., width 55 mm.	Point Sinclair, South Australia.
Height 67 mm., width 38 mm.	Hardwicke Bay, South Australia.
Height 66 mm., width 34 mm.	Reevesby Island, South Australia.
Height 125 mm., width 63 mm.	Beachport, South Australia.
Height 61 mm., width 31 mm.	Albany, Western Australia.
Height 33 mm., width 20 mm.	Bunbury, Western Australia.
Height 63 mm., width 36 mm.	Port Fairy, Victoria.

Tritonium tabulatum Menke 1843, described from Western Australia, was said to be intermediate between *pileare* and *cutacea* and it is probably a juvenile of *waterhousei,* about 1⅓″ long, but the name could be used subspecifically for the Western Australian form, which appears to be noticeably smaller.

CABESTANIMORPHA EXARATA Reeve 1844)

Triton exaratum Reeve 1844, Proc. Zool. Soc., 116.

Loc.—North Australia (type). Queensland. South Pacific. New South Wales. Victoria. South Australia: Guichen Bay, MacDonnell Bay, Robe. Western Australia: Albany, Bunbury, Ellenbrook, Cambridge Gulf, Fremantle 10 to 12 fms., Yallingup, Cottesloe.

Remarks—This North Australian species ranges down the western coast to Cape Leeuwin, and down the eastern coast round to the South-East of South Australia, but along the southern coast between these two points it has not been taken, nor has it been taken in Tasmania. Specimens from Albany range up to 45 mm. in height.

Cabestanimorpha euclia sp. nov.

(Fig. 2)

Shell small, thin, whorls shouldered above, crossed by weak roundly flattened major spiral ribs, about five on the body-whorl with obsolete fine spirals between and splitting them; spiral, sculpture finely undulated by regular weak axial grooves: the two rather more bold shoulder ribs carrying twin tubercles, where six obsolete axial undulations cross the major spirals, forming six pairs on the body whorl and correspondingly fewer on the spire; outer lip varix thin but well folded in; the next varix almost directly above but slightly to the left of the columella axis; aperture rather wide and pyriform produced into a long, narrow slightly sinuous anterior canal; protoconch long of four highly polished shelly whorls, very slowly increasing in size. Height 20 mm., diameter 12 mm.

Loc.—Western Australia: nine miles west of Eucla, 100 fms (type); 80 miles west of Eucla, 81 fms.

Remarks—Three adults and a couple of fragmentary juveniles. At first the species was thought to be *elongatus* Reeve or *vespaceum* Lamarck, from the shape and long canal. It is, however, quite distinct and may be a deep water species related to *exarata*. Holotype, Reg. No. D. 6515, S. Aust. Museum.

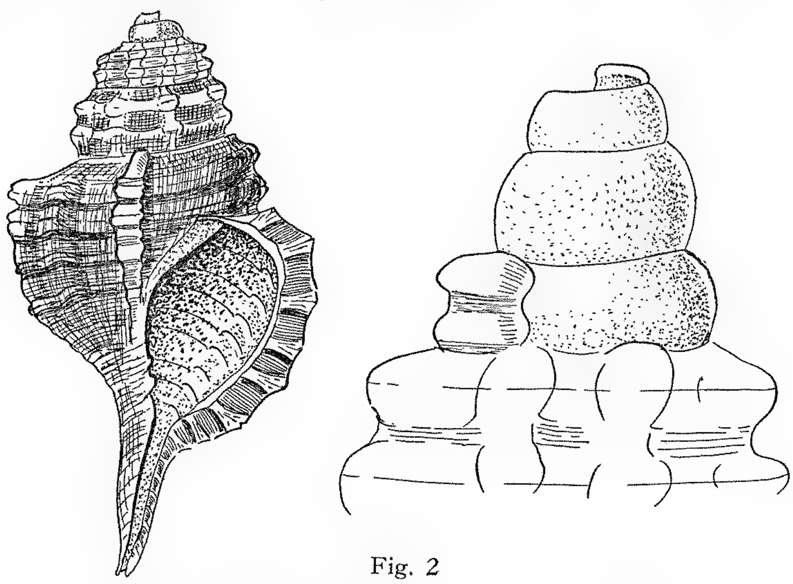

Fig. 2
Cabestanimorpha euclia sp. nov., adult shell and protoconch

MONOPLEX PARTHENOPIUM (von Salis 1793)

Murex parthenopium von Salis 1793, Reis Neap., 370, pl. vii, fig. 1.

Loc.—New South Wales. Victoria. New Zealand.

Remarks—Hedley recorded this from the Great Australian Bight, 80 to 120 fms., Western Australia. After careful searching in the Verco and May collections, I can find no specimens of this species from Western Australia, South Australia or Tasmania, either from shallow or deep water. The distribution is apparently somewhat similar to that of *Cabestanimorpha exarata*, except that the present species does not occur even in the South-East of South Australia.

PARTICYMATIUM LABIOSUM (Wood 1828)

Murex labiosum Wood 1828, Suppl. Index Test., 15, pl. v, fig. 18.

Loc.—New South Wales (type). Queensland: Moreton Bay.

Remarks—Iredale 1936, Rec. Aust. Mus., 19, No. 5, remarked upon the resemblance of Wood's figure to the Sydney shell known as *strangei* Adams and Angas 1864, which is probably a synonym, and the New Zealand so-called "*labiosum*," a distinct species.

PARTICYMATIUM GEMMATUM Reeve 1844

Triton gemmatum Reeve 1844, Conch. Icon., 2, pl. xv, fig. 60 a.

Loc.—Philippines (type). Western Australia: Shark Bay. North Australia: Murray Island. Queensland.

NEGYRINA SUBDISTORTA (Lamarck 1822)

Triton subdistorta Lamarck 1822, An. S. Vert., 7, 186.

Loc.—New South Wales. Victoria. Tasmania. South Australia (type): Kangaroo Island; St. Francis Island; Robe; dredged Beachport, 40 fms.; Yan-

kalilla Bay, 10 to 15 fms.; Corny Point, 27 fms.; Investigator Strait, 19 fms.; Backstairs Passage, 17 to 20 fms.; Royston Head, 22 fms.; Newland Head, 20 fms.; Spencer Gulf, 12½ fms.; alive down to 22 fms.

Remarks—Typical specimens are taken in South Australia. Reeve gives "Port Adelaide and King George's Sound" as localities, but although common in South Australia I have never seen a single specimen from Western Australia or from further west than St. Francis Island. It has never been taken with the protoconch present however small the living specimen, so that it must be very early deciduous. The periostracum has very short, close-set hairs arranged in both axial and spiral lines. The aperture varies very greatly. In some examples of even large size there is scarcely any labial callus and the labrum shows only the gutter of the varix. In others the mouth is almost completely circular and funnel-shaped, the outer lip expanded and somewhat reflected; the inner lip has a wide-spread parietal callus, which is free and expanded over the columella into a wide sloping lamina.

Negyrina delecta sp. nov.

(Fig. 1 D)

Shell small, fusiform, thick, whorls slightly asymetrical, rounded, scarcely angled; colour cream with a system of numerous intergranular reddish-brown dots, the small granules themselves cream; sculpture consisting of numerous series of small granules arranged in spiral; alternate spirals with slightly larger or smaller granules; at the rounded shoulder of the body whorl there is a tendency to form a row or two of a little more prominent tubercules; varices low rounded ribs, seven in number; aperture small and rounded, inner lip ridged within, slightly effuse but well within the border of the last varix; columella spread with a thin glazed reflection of the inner lip; anterior canal short and narrow. Height 45 mm., diameter 24 mm.

Loc.—South Australia: Middleton (type), St. Francis Island, Kangaroo Island, Point Sinclair.

Remarks—Holotype, Reg. No. D. 14202, S. Aust. Museum. This species is distinguished from *subdistorta* by the smaller, more solid shell, rounded not shouldered whorls, the distinctive colour pattern, small aperture and short anterior canal. When taken alive it is a beautiful shell, generally of a light yellowish-orange tint with spiral series of square dark purple black spots varying in size in different spirals and occupying the spaces between the small nodulations; sometimes the ground colour is light purple. This species does not appear to be dredged in depths below 5 fms. and is essentially littoral. Juveniles are consistently different and easily distinguished from those of *subdistorta*. The protoconch, as in *subdistorta*, is early deciduous, and no adults or juveniles in the collection retain it.

Negyrina petulans (Hedley and May 1908)

Septa petulans Hedley and May 1908, Rec. Aust. Mus., 7, No. 2, 118, pl. xxiii, fig. 16.

Loc.—Tasmania: Pirates Bay Beach, near Cape Pillar (type loc.). South Australia: Beachport, 150 and 200 fms. Victoria: Port Fairy.

Remarks—The broken specimen from 200 fms. on which Verco based the South Australian record is before me and appears similar to May's "cotypes' from 100 fms. seven miles east of Cape Pillar and a living specimen from 80 fms. 10 miles east of Schouten Island, but I have not seen May's holotype in the Hobart Museum, which is said to have been taken on the beach. Two further poor broken specimens separated from dredged material taken in 200 fms. off Beachport show variation, being more strongly noduled at the shoulder of the whorls, but still agreeing with the Tasmanian specimens in size and general

features. It would seem that the holotype of *petulans*, according to Hedley and May's figure, is an extreme variant in which the nodules are reduced, our South Australian forms covering both extremes. Three perfect, fresh specimens, the best I have seen, have the locality Victoria? Kenyon Collection.

CYMATOMA KAMPYLA (Watson 1886)

Nassaria kampyla Watson 1886, Journ. Linn. Soc. Lond., **16**, 594.

Loc.—New South Wales: off Sydney, 410 fms. (type). Victoria. Tasmania, 30 and 100 fms. South Australia: Beachport to Cape Jaffa, 90 to 200 fms.

Remarks—There are two distinct variants of the species in South Australia, found in the same localities and depths:

(*a*) Nearest to typical *kampyla*. Protoconch large and similar to (*b*), but generally more sturdy. Shell more solid, anterior canal shorter, less curved; sculpture more valid.

(*b*) Thinner and less sturdy, sculpture less valid, longer in proportion to the width than in the typical *kampyla*.

The type locality of *Lampusia nodocostata* Tate and May 1900 was "East coast of Tasmania," and it is a direct synonym of *kampyla*. We have a good series from 100 fms. off Cape Pillar and 30 fms. off Storm Bay, Tasmania.

GONDWANULA BASSI (Angas 1869)

Triton bassi Angas 1869, Proc. Zool. Soc., 45, pl. ii, fig. 3.

(Fig. 1 B-C)

Loc.—Victoria: Bass Straits (type). Tasmania: North Coast. South Australia: Eastern Cove, Kangaroo Island; Point Sinclair; St. Francis Island; dredged Beachport, 110 fms.; Gulf St. Vincent, 14 and 17 fms.

Remarks—The species is rare but has been taken alive on rocky beaches at Point Sinclair, the shell being purplish-brown, but white in specimens dead on the beach.

South Australian specimens are much less nodulated than the Tasmanian shell and the spiral ridges are much wider and flatter. South Australian shells have only two nodules, Tasmanian six or seven and much sharper. Tasmanians have also two finer angulations anteriorly, which are finely tuberculated; these are absent in South Australian shells. The embryonic shell, unlike that of *Negyrina subdistorta* is usually present, being blunt and rounded. Living specimens dredged in Backstairs Passage, 17 fms., have an ovate not acute operculum, with the nucleus anterior, a little external to the middle line. The foot is about one-half the length of the shell and about half as broad as long, of a dull yellowish-white colour tinted with red in minute spots at the posterior extremity. The tentacles are about as long as the foot is wide, of a crimson red colour and with the black eyes on their outer sides at about one-quarter of their length from the bases of the tentacles, which are white for a short distance immediately below the eyes.

GONDAWANULA FRATERCULUS (Dunker 1871)

Triton fraterculus Dunker 1871, Malak. Blatt., 166.

Loc.—South Australia: Thorny Passage, 25 fms.; Tunk Head; St. Francis Island, 15-20 fms.; Point Sinclair (Weeding). Victoria: Bass Straits (type).

Remarks—The species appear to occur as far west as St. Francis Island. It is not represented in any Western Australian material I have examined. *Sipho mimeticus* Tate 1893, holotype from Tapley's Shoal, eight miles off Edithburgh, 12 to 16 fms., is a synonym.

GONDWANULA TUMIDA (Dunker 1862)

Ranella tumida Dunker 1862, Proc. Zool. Soc., 239.

Loc.—Tasmania (type). Victoria. Western Australia. South Australia: Port MacDonnell, Pondolowie Bay.

Remarks—There are two small beach-worn specimens in the collection, one from "Middleton" and one from "MacDonnell Bay," both of doubtful origin, and there are two specimens in the Elliott Collection from Middleton and Pondolowie Bay.

CYMATIELLA VERRUCOSA Reeve 1844

Triton verrucosus Reeve 1844 Conch. Icon., Triton, pl. xvii, fig. 71.

Loc.—Victoria (type). Tasmania. South Australia: Port MacDonnell; Pondolowie Bay; Streaky Bay; dredged Backstairs Passage, 20 fms.; Cape Borda, 55 fms. and 60 fms.; Cape Jaffa, 130 fms.; Beachport, 40 fms and 110 fms.; Ardrossan, 14 fms.; Wallaroo, 15 fms.

Remarks—The species is distinguished by the coarse sculpture and well open wide mouth. It is probably less common than the very plentiful *gaimardi.* No specimens from Western Australia have been seen by me. *Triton quoyi* Reeve 1844 is a synonym.

CYMATIELLA GAIMARDI (Iredale 1929)

Cymatiella gaimardi Iredale 1929, Rec. Aust. Mus., 17, No. 4, 174, pl. xl, fig. 7.

Loc. — South Australia: Port Lincoln (type); Normanville; Kangaroo Island, American River; Encounter Bay; Robe; Troubridge; Gulf St. Vincent; Spencer Gulf; Henley Beach; Glenelg; Port Wakefield; Point Sinclair; dredged, Yankalilla Bay, 10 to 15 fms.; Rapid Head, 9 to 12 fms.; Port Lincoln, 9 fms.; Corny Point, 30 fms.; Hardwicke Bay, 8 to 10 fms.; St. Vincent Gulf, 5, 7, 9, 15 and 17 fms.; Investigator Straits, 13 fms. and 15 fms.; Backstairs Passage, 16 fms.; Eastern Cove, Kangaroo Island, 11 and 14 fms.; Spencer Gulf, 20 fms.; Porpoise Head, 17 fms.; Newland Head, 20 fms.; alive down to 30 fms. Western Australia: Esperance Bay; Hopetoun.

Remarks—Shell narrower, more attenuate than *verrucosa,* aperture smaller and more closed, sculpture coarse. This species is common in South Australia. Examples from Pondolowie Bay, Spencer Gulf, have a dark brown crescentic blotch at the extreme upper end of the labial varix, and so indicate throughout the spire the site of previous labial varices. Shells from St. Francis Island, Esperance and Hopetoun are prettily decorated with spiral brown bands and dots.

CYMATIELLA LESUEURI Iredale 1929

Cymatiella lesueuri Iredale 1929, Rec. Aust. Mus., 17, No. 4, 175, pl. xl, fig. 11.

Loc.—Victoria: Port Phillip (type). East Tasmania. South Australia: Middleton; Robe; St. Francis Island; Gulf St. Vincent; Spencer Gulf; Beachport, 40 fms.; Backstairs Passage, 22 fms.; Middleton, 10 fms. Western Australia: Hopetoun; Yallingup; Rottnest.

Remarks—Although comparatively common in South Australia I have seen only three specimens, one from each locality mentioned, in Western Australia.

CYMATIELLA COLUMNARIA (Hedley and May 1908)

Cymatium columnarium Hedley and May 1908, Rec. Aust. Mus., 7, No. 2, 119, pl. xxiii, fig. 15.

Loc.—Tasmania: Cape Pillar, 100 fms. (type); south and east coasts. South Australia: Beachport, 40, 100, 110, 150 and 200 fms.; Cape Jaffa, 130

fms.; Cape Borda, 60 fms.; Neptunes, 104 fms. Western Australia: West of Eucla, Great Australian Bight, 50 to 120 fms., 100 fms., and 75 fms. off Beachport.

Remarks—Probably a deep water form of *gaimardi.*

RATIFUSUS MESTAYERAE Iredale 1915

Ratifusus mestayerae Iredale 1915, Trans. N.Z. Inst., **47**, 466.

Loc.—New Caledonia (type). New South Wales. Victoria. Tasmania. South Australia: Port MacDonnell. Western Australia: Albany.

Remarks—The species is not uncommon in the South-East of South Australia but I have not seen it from elsewhere in the State.

RATIFUSUS ADJUNCTUS Iredale 1929

Ratifusus adjunctus Iredale 1929, Rec. Aust. Mus., **17**, (4), 183, pl. xl, fig. 5.

Loc.—New South Wales: Montague Island, 50-60 fms. (type). South Australia: Beachport, 110, 150 fms. and 200 fms.

Remarks—A perfect South Australian specimen is half as big again as the holotype, being 25 mm. in length and appears to have finer sculpture and a slightly wider aperture. Hedley 1911 recorded *schoutanicus* May from Cape Wiles 100 fms., but I have not seen specimens from South Australia, and as the species is merely listed it is questionable whether the species is *schoutanicus* or the deeper water Eastern Victoria *conterminus* from 100-250 fms. of East Victoria.

RATIFUSUS BEDNALLI (Brazier 1875)

Colubraria bednalli Brazier 1875, Proc. Linn. Soc. N.S.W., 6.

Loc. South Australia: Guichen Bay (type), Gulf St. Vincent and Spencer Gulf; Encounter Bay; Robe; MacDonnell Bay; Corny Point; Daly Head; dredged Beachport 40, 110, 150 and 200 fms.; Cape Jaffa, 130 fms.; Cape Borda, 55 fms.; Backstairs Passage, 16, 18, 19, 20 and 22 fms.; Newland Head 20 fms.; Porpoise Head, 12 fms. Western Australia: Rottnest. Victoria: Western Port.

Remarks—Specimens from 40 fathoms and below show a rather different sculpture, the longitudinal sculpturing predominating, but the difference is not consistent. The species is plentiful in South Australia, especially on open ocean beaches, but rarer in Gulf St. Vincent.

CHARONIA RUBICUNDA (Perry 1811)

Septa rubicunda Perry 1811, Conchology, pl. xiv, fig. 4.

Loc.—New South Wales (type). Queensland. Victoria. Tasmania. South Australia: Kangaroo Island; Thistle Island; Outer Harbour. Western Australia: Ellenbrook; Albany; Bunbury; Yallingup.

Remarks—A specimen of this Australian species in our collection from Albany is the typical shallow water form, measuring 192 mm. x 115 mm., and similar specimens are represented from Ellenbrook up to 175 mm. x 85 mm. The shell is taken alive off Kangaroo Island, and the Outer Harbour record is probably due to a specimen having been tossed out there from a crayfish boat, returning from Kangaroo Island. The shell grows large and thick in the Flindersian Region, a specimen from Kangaroo Island measuring 210 mm. x 110 mm.

CHARONIA EUCLIA Hedley 1914

Charonia nodifera euclia Hedley 1914, Zool. Res. Endeavour, **2**, 65, pl. viii.

Loc.—Western Australia: Great Australian Bight, 80-120 fms. (type), 100 fms. (Verco); dredged, Albany; Rottnest.

Remarks—This species is not necessarily distinguished from *rubicunda* by the narrow form, for both wide and narrow variants of the latter shore species occur right along the Southern Australian shore line from South Australia to South Western Australia, one from Bunbury measuring 170 x 90 mm., and one from Ellenbrook 170 x 80 mm., both living specimens. The five specimens of *euclia* before me, dredged in the Great Australian Bight, are consistent in the delicacy of the shell and sculpture and paleness of the ornament. Though they vary considerably in relative width, they tend to be narrower than typical shore shells of *rubicunda*. Their form is not a matter of East and West latitude, but probably the result of environment in the quiet depths of 100 fms. on a sandy bottom instead of among rocks on a shore-line. But while searching through the collection I came across a large specimen from Middle River, Kangaroo Island, measuring 210 x 115 mm., which approached *euclia* in size and delicacy and must have measured about 230 mm. in length when complete, thus approximating to the proportions of dredged specimens from the Great Australian Bight. Turning up some old manuscript notes of Verco's, I found the following: "Mr. George Pattison of Cape de Coudie Lighthouse sent Mr. Ashby an example of *Charonia lampas* var. *euclia* in January 1923, which he submitted to me for discussion, and he returned it to the sender with my comments. On Feb. 4 1923 Mr. Pattison wrote to Mr. Ashby as follows"; then the following quotation occurs from Pattison's letter: "The shell was found by myself at Cape de Coudie, Kangaroo Island, on 10 November 1922. I was wading in the sea turning over rocks at low water mark, when I discovered the shell under a rock with the fish alive in it. There were also numerous broken shells of the same species, about seven or eight. Today, being a fairly low tide, I climbed down the cliff and hunted for some live ones. I found two alive and one shell without a fish in it. By what I have observed, I should say that given an extra low tide one could find plenty of specimens." Mr. Pattison's specimen must have been similar to the Middle River specimen before me, which is but slightly heavier than true *euclia*.

I can only suggest that the narrower lighter shell is distinct and is represented in shallow and deep water, the true *euclia* Hedley being the deep water form of a narrower and more delicate species related to *rubicunda*.

Mayena australasia (Perry 1811)

Biplex australasia Perry 1811, Conch., pl. iv, fig. 2, 4, = *leucostoma* Lamarck 1822.

Loc.—South Australia: Corny Point; Middleton; Robe. Western Australia: Ellenbrook; Rottnest. New South Wales (type).

Remarks—Only three specimens of this species have been seen from South Australia, two beach-worn and one in living condition. It was recorded from Middleton by Adcock, and Yorke Peninsula by Matthews, but I have never dredged it in South Australia and have only taken the one beach-worn specimen at Robe. At Ellenbrook a good series of typical specimens ranging from very small to about 80 mm. by 45 mm., and one from Rottnest. All are similar in form and sculpture to the Tasmanian shells. While apparently common in Western Australia and Eastern Australia, it seems to be extremely rare in South Australia.

Mayena euclia sp. nov.

(Fig. 3)

Shell long, narrow, solid, white with yellowish thin periostracum like coarse muslin, with a minute, erect hair at each intersection; between the larger nodules there is a sparse nut-brown maculation; four rows of nodules beneath the major shoulder row appear on the ventral surface of the body whorl; spire one and a half times the height of the aperture; aperture small, rounded, strongly dentate

except at the middle of the columella; canal long and strongly dentate on the columella side; protoconch (from the juvenile specimen) conical, of four sloping convex whorls, the minute extreme apex absent. Height 90 mm., diameter 43 mm.

Loc.—Western Australia; west of Eucla; Great Australian Bight, 100 fms.

Remarks—Holotype D. 6771, South Australian Museum. The holotype and one juvenile specimen were both briefly recorded by Verco 1912, Trans. Roy. Soc. S. Aust., 36, 220, under the name *Argobuccinum australasia.* The specimens are very different from *australasia* in every way. It is long and narrow and has a long anterior canal. It recalls *benthicola* Iredale 1929 from the continental shelf of Eastern Australia, but is even narrower and has a longer and straighter anterior canal.

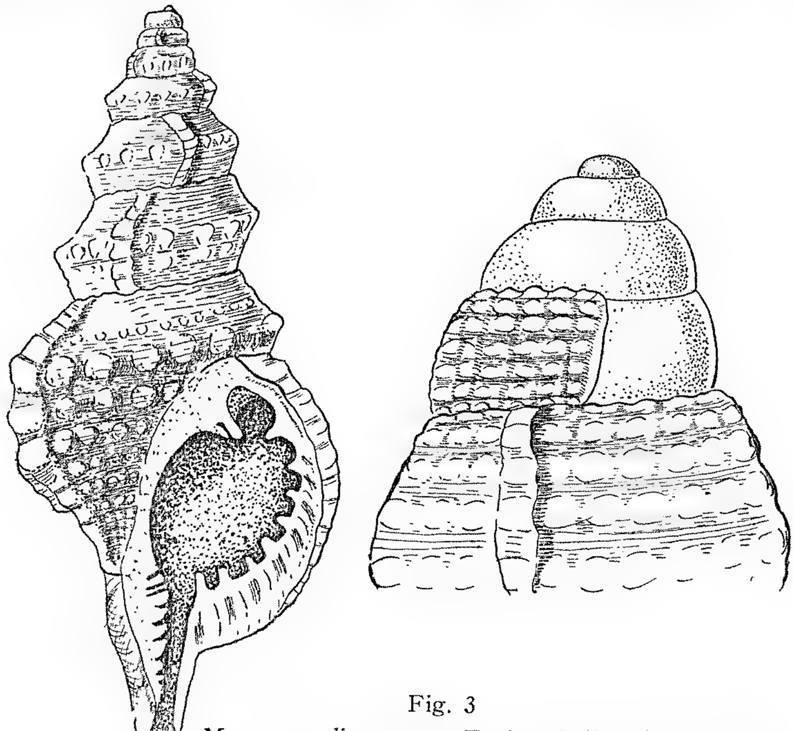

Fig. 3
Mayena euclia sp. nov. Entire shell and protoconch

APOLLON GYRINUS (Linné 1758)

Murex gyrinus Linné 1758, Syst. Nat. Ed., 10, 748.

Loc.—North Australia: Gulf of Carpentaria; Murray Island.

Australian species of CYMATIDAE are here tabulated

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas.	N. Tas.	S. Pac.	Ind. Oc.
Cymatium Bolten 1798—																		
*femorale** Linné 1758	S	Not Australian. Type loc., West Indies																
lotorium Linné 1758	S	X	X														X	T
sarcostoma Reeve 1844 ..	S	X	X														T	
encausticum Reeve 1844 ..	S		X														T	
moritinctum Reeve 1822 ..	S		X														T	
pfeifferianum Reeve 1844	S		X															
tuberosum Lamarck 1822 ..	S		X									X					X	T
gracile Reeve 1844	S		X														T	

Australian CYMATIIDAE (continued)

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W.	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas.	N. Tas.	S. Pac.	Ind. Oc.
chlorostoma Lamarck 1822	S	x	x	x													x	
Cymatilesta Iredale 1936—																		
*spengleri** Perry 1811	S			x	x	T												
barthelemyi Bernardi 1857	S						x	T	x				x	x	x	x		
procurum Iredale 1929	drdgd.																	
boltenianum Adams 1854	S					T												
waterhousei Ad. & Ang. 1865	0-40								x	T								
subsp. *tabulatum* Menke 1843	S										T							
frigidulum Iredale 1929	drdgd.					T												
tepida Iredale 1936	S					T												
Cabestanimorpha Iredale 1936																		
*exarata** Reeve 1844	0-12	T	x	x	x	x					x	x						
vespacea Lamarck 1822	S									x	T?							
euclia Cotton 1945	81-100										T							
elongata Reeve 1844	S		x														T	
Monoplex Perry 1811—																		
*partheropium** von Salis 1793	S			x	x	T?	x	x										
Lampusia Schumaker 1817																		
*pilearis** Linné 1758	S					Type loc., Mediterranean												
aquatilis Reeve 1844	S	x	x									x					T	
nicobarica Bolten 1798	S	x	x	x	x												T	
Tritonocauda Dall 1904—																		
*caudata** Gmelin 1791	S	x																T
vulticula Iredale 1936	S					T												
Ranularia Schumaker 1817—																		
*clavator** Lamarck 1822	S																T	
pyrum Linné 1758	S	x	x	x	x													T
sinense Reeve 1844	S	x	x	x	x		Type loc., China											
defrenata Iredale 1936	S				x	T												
Particymatium Iredale 1936—																		
*labiosum** Wood 1828	S			x	x	T												
gemmatum Reeve 1844	S		x														T	
rutilum Menke 1843	S										T							
zimara Iredale 1929	S					T												
Septa Perry 1810—																		
*rubecula** Linné 1758		x	x														T	
blacketi Iredale 1936						T												
Distorsio Bolten 1798—																		
*anus** Linné 1758	S		x	x													T	
francesae Iredale 1931	S		x	x		T											x	
Austrosassia Finlay 1931 —																		
*parkinsoniana** Perry 1811	S					T							x	x				
basilicus Iredale 1924	50-70					T												
Negyrina Iredale 1929—																		
*subdistorta** Lamarck 1822	0-40					x	x	x	T				x		x	x		
delecta Cotton 1945	S								T	x								
petulans Hedley & May 1908	0-200							x	x				T	x				
Cymatoma Iredale 1929—																		
*kampyla** Watson 1886	90-410						T	x	x	x			x	x	x	x		
Phanozesta Iredale 1936—																		
*remensa** Iredale 1936	110					T												

Australian CYMATIIDAE (continued)

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W.	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas.	N. Tas.	S. Pac.	Ind. Oc.
Gondwanula Finlay 1926—																		
*tumida** Dunker 1862	S						x	x	x	x			x	x	x	x	x	
bassi Angas 1869	0-110						T	x	x	x						x		
fraterculus Dunker 1871	0-25						T	x	x	x								
Cymatiella Iredale 1924—																		
*verrucosa** Reeve 1844	0-110						x	T	x	x								
peroniana Iredale 1929	50-60					T												
columnaria Hed. & May 1908	40-100								x	x	x		T					
gaimardi Iredale 1929	0-30								x	T	x							
lesueuri Iredale 1929	S						T	x	x	x	x		x					
eburnea Reeve 1844	S							Not Australian									T	
Obex Iredale 1925—																		
*mulveyanum** Iredale 1925	74					T												
brazieri Angas 1869	S				x	T												
Ratifusus Iredale 1929—																		
*adjunctus** Iredale 1929	50-60					T					x							
mestayerae Iredale 1915	S					x	x	x	x		x	Type loc., N. Caled.						
schoutanicus May 1910	75-80					x	x						T					
conterminus Iredale 1925	100-250						T											
bednalli Brazier 1875	0-200								T	x	x							
volaticus Iredale 1925	S				x	T	x											
Apollon Montfort 1810—																		
*gyrinus** Linné 1758	S	x	x	x														
affine Broderip 1833			x															
ranelloides Reeve 1844			x								x							
Gyrinella Dall 1924—																		
*pusilla** Broderip 1832	S				Type loc., Lord Hood Island													
facetus Iredale 1936	S		x	x	x	T												
deliberatus Iredale 1936	S		T															
Fusitriton Cossmann 1903—																		
*cancellatum** Lamarck						Type loc., West Indies												
retiolus Hedley 1914	50-410					x	T											
laudandum Finlay 1926	40					Type loc., New Zealand												
Charonia Gistel 1848—																		
*tritonis** Linné 1758	S	x	x	x			Type loc., West Indies										x	x
rubicunda Perry 1811	S			x	x	T	x	x	x	x	x	x	x		x	x		
euclia Hedley 1914	80-120					x	x	x	x	x	T							
instructa Iredale 1929	50-79					T												
Vernotriton Iredale 1936—																		
pumilio Hedley 1903	0-22				T													
Mayena Iredale 1917—																		
*australasia** Perry 1811						T	x	x	x	x	x							
benthicola Iredale 1929	drdgd.					T												
euclia Cotton 1945	100										T							

Family BURSIDAE

DULCERONA JABICK (Bolten 1798)

Tritonium jabick Bolten 1798, Mus. Bolt., 127.

Loc.—New South Wales (type). Western Australia: Rottnest; Albany; Ellenbrook. South Australia: Kangaroo Island, dredged.

Remarks—Synonyms are *granifera* Lamarck 1816 and *granularis* Bolten 1798, the latter introduced on the same page but following *jabick*. A single living, perfect specimen dredged by Verco at Nepean Bay, Kangaroo Island, was mixed with some *subdistorta*.

The Australian species of BURSIDAE are as follows:

Genus and Species	Depth	N.A.	N.Q.	S.Q.	N. N.S.W	S. N.S.W	E. Vict.	W. Vict.	E. S.A.	W. S.A.	S. W.A.	N. W.A.	E. Tas.	S. Tas.	W. Tas.	N. Tas.	S. Pac.	Ind. Oc.
Bursa Bolten 1798—																		
*bufonius** Gmelin 1791 ..	S							Not Australian									x	T
rana Linné 1758	S	x	x	x														
=*crumena* Lamarck 1822	S																	
mammaria Bolten 1798 ..	S		x	x	x													
venustula Reeve 1844	S		x	x														
bituberculatus Lamarck 1822	S		x					Type loc., Philippines										
Tutufa Jousseaume 1881—																		
bufo Bolten 1798	S		x	x														
lissostoma Smith 1914 ..	S				x	x												
Gyrineum Link 1807—																		
*spinosa** Lamarck 1843 ..	S							Not Australian										T
procator Iredale 1931	drdgd.					T												
cavitensis Reeve 1844	S																T	
Dulcerona Iredale 1931—																		
jabick Bolten 1798	S					T			x		x							
=*granularis* Bolten 1798 ..																		
=*granifera* Lamarck 1816 ..																		
Annoporenna Iredale 1936 ..																		
*verrucosa** Sowerby 1825 ..	S		x	x	x	x		Type loc., Norfolk Island										
Argobuccinum Bruguière 1792																		
succinctum Linné 1771 ..				x	x													

Family TONNIDAE

TONNA VARIEGATA (Lamarck 1822)

Dolium variegata Lamarck 1822, An. c. Vert., **7**, 261.

Loc.—Western Australia: Shark Bay (type); 80 miles west of Eucla, 100 fms.; Rottnest; Ellenbrook.

Remarks—Fragments of shell from the last two localities.

Family FICIDAE

FICUS EOSPILA (Peron 1807)

Pyrula eospila Peron 1807, Voy. Terre Austral., **1**, 132.

Loc.—Western Australia: Depuch Island (type); Rottnest; 90 miles west of Eucla, 100 fms.

Remarks—A fragment only from Rottnest.

SUMMARY

Four new species are described and the figure of a previously described species is given. Notes and exact locality records of twenty-four other species are also recorded, while complete lists of Australian Cassididae, Cymatiidae and Bursidae are added.

GRANITES OF THE TINTINARA DISTRICT

BY D. MAWSON AND E. R. SEGNIT (READ 13 SEPTEMBER 1945)

Summary

This contribution deals with the distribution and nature of granite outcrops yet to be described in the remaining section of the Uper South-Eastern District of South Australia. Other areas have been dealt with in publications 2 and 3 of the list of references on page 276. The area now concerned lies to the west of Tintinara Railway Station, between the Adelaide to Bordertown railway track and the Coorong (see map, p.264). Most of this area is covered with low scrub, difficult to traverse except on foot or horseback on account of the absence, except in the approaches to Tintinara, of tracks passable to wheeled transport.

We have located on the map a large number of granite outcrops and believe that few, if any, that appear above the soil and ancient drift sand covering of that region have been overlooked. These new records are part of the extensive batholythic belt which we have now traced from Murray Bridge almost to Bordertown.

GRANITES OF THE TINTINARA DISTRICT

By D. Mawson and E. R. Segnit

Plates XVI to XVIII

[Read 13 September 1945]

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This contribution deals with the distribution and nature of granite outcrops yet to be described in the remaining section of the Upper South-Eastern District of South Australia. Other areas have been dealt with in publications 2 and 3 of the list of references on page 276. The area now concerned lies to the west of Tintinara Railway Station, between the Adelaide to Bordertown railway track and the Coorong (see map, p. 264). Most of this area is covered with low scrub, difficult to traverse except on foot or horseback on account of the absence, except in the approaches to Tintinara, of tracks passable to wheeled transport.

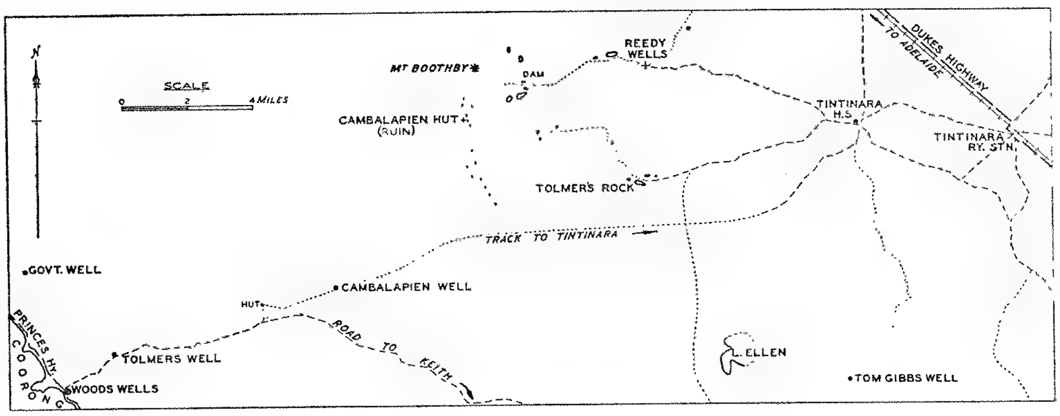
We have located on the map a large number of granite outcrops and believe that few, if any, that appear above the soil and ancient drift sand covering of that region have been overlooked. These new records are part of the extensive batholythic belt which we have now traced from Murray Bridge almost to Bordertown.

THE FORM AND DISTRIBUTION OF OUTCROPS

The outcropping granite masses are nearly all individually of very restricted area, many of them being no more than a single rock like those in the illustrative plates herewith or, at the most, a group of several of such monoliths or whalebacks. These rock masses usually project to heights of 10 to 30 feet above the surrounding plain which is diversified by very little relief; such as there is of the latter being mainly in the nature of rises of drift sand on which there is sometimes developed a thin calcareous crust. Our extended field experience in that region has led to the conclusion that this ancient granite is distributed very widely, located either directly beneath the Pleistocene and Recent unconsolidated sediments or separated from them only by a thin formation of Miocene to later Tertiary limestone.

Again we record that our search for outcropping granite has been assisted by the recognition that patches and belts of timber among the ubiquitous low scrub

always indicate the close approach to the surface of granite or other pre-Pleistocene formations. In this region of porous, unconsolidated or but poorly consolidated surface formations, we have found granite basements to be most effective in establishing forest growths. This, of course, can happen only where the granite outcrops either at the surface or is disposed at shallow depth. This appears to be due to two factors: firstly, the underlying granite surface prevents such rain as falls in that dry district from sinking to depths out of reach of tree roots; secondly, the granite supplies certain mineral deficiencies which are so marked a feature of the sandy and calcareous regolith in the Coorong area.



The granite outcrops are distributed among stunted forest timber, and rarely amount to more than isolated tors. They range up to a height of about 25 to 30 feet, but some are low whalebacks, and these are the most difficult to locate.

As the outcrops rarely rise above tree height they are not observed until closely approached. Individual masses are presented in a variety of shapes, apparently the result of long continued subaerial weathering under semi-arid conditions. Their northern faces, which receive the full heat of the sun, have developed a resistant case-hardened surface. On their southern faces weathering of the feldspars has progressed normally, assisting in the crumbling of the rock. Thus it is that the southern faces of tors and the underneath surfaces of supported boulders are sometimes hollowed out (see pl. xvii, fig. 2). Tall monolithic forms are quite abundant.

THE CAMBALAPIEN OUTCROPS

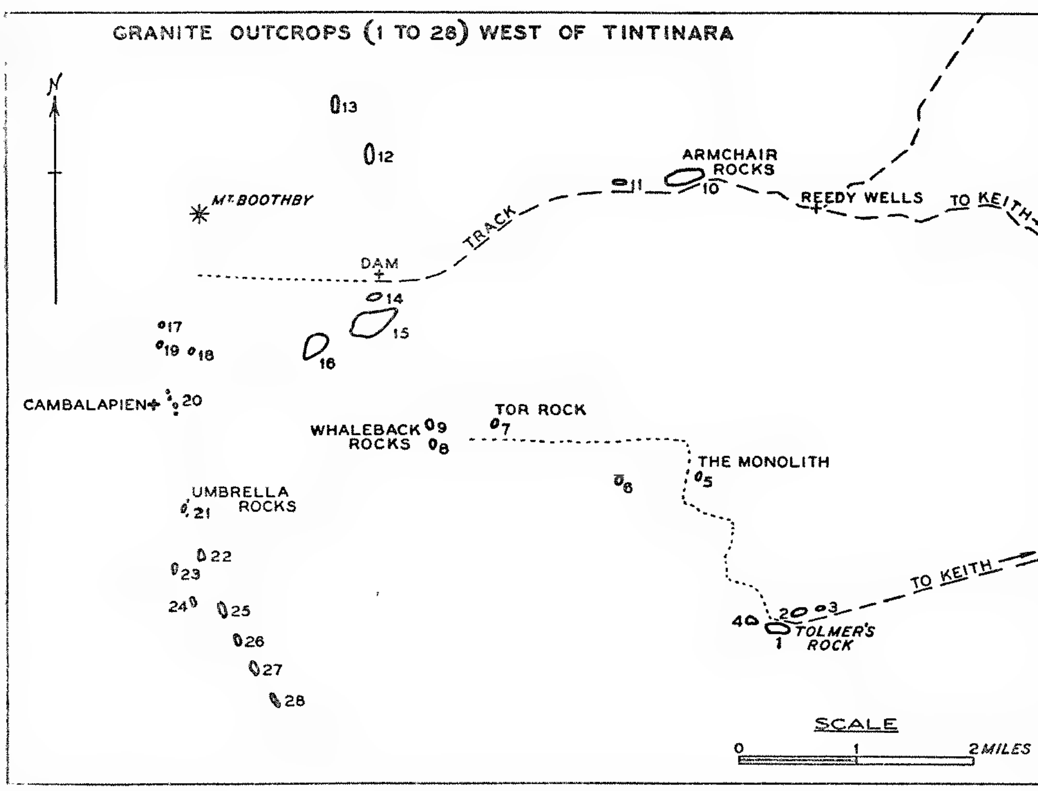
A ridge elevated one or two hundred feet above the general level of the surrounding country extends southward to Mount Boothby from the area of granite outcropping at Crotty's Knob and Binnie's Lookout. Though outcrops have not been located between Crotty's Knob and Mount Boothby, there is good reason to believe that granite, at moderate depth, does underly the surface sands and travertine crusts of that belt of country.

To the south, beyond Mount Boothby, the ridge gradually fades out within a couple of miles. In this area, however, the underlying granite comes to the surface at a number of isolated spots as indicated in the sketch map herewith (p. 265), in which each outcrop is numbered to facilitate reference in the text to follow.

The outcrops (numbers 17 to 28) on the southern end of the Mount Boothby rise are grouped together in this account as the Cambalapien outcrops. Once upon a time that region was taken up by an over-optimistic

pastoralist and named Cambalapien sheep station, only to be abandoned at a later date. The ruin of the former homestead is situated on the western side of outcrop 20.

Outcrop 18 is no more than a low ledge about 40 yards across. Outcrop 20 consists of a group of upstanding tors and crags aligned in an approximately north to south direction, covering a length of almost 500 yards by a width of 200 yards. Tors are met with as much as 22 yards long by 30 feet in height; where they are upstanding, the profile of the northern face of each of the masses is of convex curvature, while the southern face is an almost vertical wall. At the extreme south end of this chain the rock is of finer grain. The rock of some parts of the



GRANITE OUTCROPS (1 TO 28) WEST OF TINTINARA

outcrop is better described as a microgranite; in some places it is miarolitic. Veins containing green fluorspar occur in one of the Cambalapien outcrops.

Outcrop 21 is a comparatively high craggy mass with some cave development due to weathering along joints. One feature is a small umbrella-rock due to cavernous weathering on the underside of a perched tor. We were not able to visit the chain of outcrops south of 21, but by their bearings were able to plot them roughly on the map.

Petrography

Rock [5783]

A potash-soda-leucogranite, representative of outcrop 21, is the most typical and general of the Cambalapien granites. It is fine- to medium-grained and composed mainly of buff-coloured potash-feldspar, light smoky-grey quartz, subordinate off-white plagioclase, and a very little black mica.

Microscopic Observations—It is holocrystalline, allotriomorphic to hypidiomorphic granular. The coarsest constituent is perthitic orthoclase which frequently exhibits a porphyritic tendency, individuals appearing up to over 6 mm. diameter. The average diameter of the quartz and plagioclase is about 1 mm. The quartz is glassy clear but for sporadic patches with minute liquid inclusions. Occasionally to be observed enveloping the quartz grains are micrographic intergrowths of quartz and feldspar in which the quartz is in optical continuity with that of the central quartz grain.

The feldspar is mainly a coarse microperthite which is invariably somewhat cloudy due to incipient alteration; it often exhibits Carlsbad twinning. The plagioclase component is apparently nearly pure albite but exhibits, only to a limited degree, twinning on the albite law. The free plagioclase, which occurs in small but well-formed crystals, is also apparently almost 100% albite. Only rarely is pericline twinning evident.

Biotite is the only other constituent present in any quantity. It is in small irregular flakes averaging about 0·5 mm. diam., and exhibits strong pleochroism: X = light-yellowish brown, Y = Z = very deep brown to deep greenish-brown. Minute apatites and zircons with haloes are commonly included in the biotite. Elsewhere through the rock tiny apatites, zircons and a few specks of black iron-ore are also met with, though rarely.

A noteworthy accessory constituent is fluorite, which is usually colourless but occasionally exhibits purple spots. More usually it is associated with the biotite, occasionally idiomorphic, with the mica wrapping around it. Fluorite also appears up to 0·5 mm. diameter in association with the quartz and feldspar; one idiomorphic crystal is embedded in the quartz and certainly has every appearance of being a primary constituent of the rock.

A chemical analysis of this rock is given in the table on page 267. The mode determined by Rosiwal measurements and the calculated norm are stated below.

Mode		Norm			
Quartz	41·3	Quartz	37·38	Magnetite	0·81
Perthite	41·7	Orthoclase	28·36	Ilmenite	0·15
Albite	14·8	Albite	29·34	Calcite	0·20
Biotite	2·0	Anorthite	1·11	Fluorite	0·31
Fluorite	0·2	Corundum	1·22	H_2O	0·38
		Hypersthene	0·89		
	100·0			Total	100·15

The C.I.P.W. classification is: I. 4. 1. 2.

ROCK [5786]

Potash-soda leucogranite from the south end of outcrop 20, as viewed in the hand-specimen, is not very different from [5783] but is somewhat granophyric. With the aid of a pocket lense there can be distinguished occasional purple grains of fluorite embedded in the mica.

Microscopic Observations—The feldspars are both large microperthites, occasionally exhibiting a marginal zone rich in graphically intergrown quartz, and also plagioclase, with albite and pericline twinning, whose optical properties correspond to pure albite. A rough measurement indicates that this albite is present to the extent of about 10% by volume.

Though there is present a very little muscovite, the main bulk of the mica is greenish-brown biotite amounting to nearly 5% of the rock. Accessory minerals are fluorspar and zircon, both of which are usually in association with

TABLE A

Chemical Composition of the Granites

	I	II	III	IV	V	VI	VII
SiO_2	76·77	75·18	76·81	73·67	73·77	74·08	71·28
Al_2O_3	12·53	12·89	12·38	13·55	13·06	13·50	14·05
Fe_2O_3 ...	0·56	0·60	0·28	0·61	0·72	0·60	1·13
FeO	0·69	1·07	0·78	1·66	1·43	1·64	1·94
MnO	0·08	0·02	0·01	0·01	0·05	0·03	0·05
MgO	0·04	0·04	0·09	0·22	0·12	0·16	0·33
CaO	0·58	1·04	0·53	1·05	0·89	1·09	1·81
Na_2O	3·47	3·59	3·79	3·41	3·55	3·86	3·56
K_2O	4·83	5·06	4·70	5·01	5·44	4·19	4·78
H_2O+	0·26	0·37	0·34	0·24	0·57	0·23	0·37
H_2O-	0·12	trace	0·14	0·08	0·11	0·06	0·09
TiO_2	0·08	0·14	0·11	0·26	0·18	0·24	0·37
P_2O_5	0·03	trace	0·02	0·06	0·08	0·04	0·13
ZrO_2	0·01	—	—	trace	0·01	0·02	0·03
BaO	0·04	—	—	0·02	0·06	0·03	0·02
CO_2	0·08	—	0·03	0·23	0·16	—	0·15
F	0·14	0·15	0·10	0·14	0·04	0·16	0·09
Cl	—	—	—	0·04	trace	—	0·08
S	0·03	—	—	0·01	0·02	0·04	0·01
	100·34	100·15	100·11	100·27	100·26	99·97	100·27
Less O for F, Cl, & S	0·07	0·07	0·04	0·06	0·02	0·06	0·04
Total	100·27	100·08	100·07	100·21	100·24	99·91	100·23
Specific Gravity	2·612	2·63	2·603	2·631	2·613	2·784	2·654

I. Potash-soda leucogranite (5783) from Cambalapien (Tintinara District). Analyst: E. R. Segnit.

II. Potash-soda leucogranite (3796) from Binnie's Water (Coonalpyn District). Analyst: L. W. Parkin (see Ref. 2).

III. Potash-soda leucogranite (5785) from Section 123, Hundred of Wirrega District). Analyst: W. B. Dallwitz (see Ref. 3).

IV. Potash-soda granite (5793) from Armchair Rocks (Tintinara District). Analyst: E. R. Segnit.

V. Potash-soda quartz-porphyry (4426) from Mount Monster (Keith District). Analyst: W. B. Dallwitz (see Ref. 3).

VI. Potash-soda hornblende-biotite granite (5097) from Crotty's Knob (Coonalpyn District). Analyst: E. R. Segnit (see Ref. 2).

VII. Hornblende-biotite-adamellite (5792) from Tolmer's Rock (Tintinara District). Analyst: E. R. Segnit.

the mica. An elongate grain of colourless fluorspar 1 mm. in length was observed embedded in feldspar.

ROCK [5790]

Another type of Potash-soda leucogranite, from outcrop 20, is strongly granophyric while finer and more irregular in grainsize than [5873]. Its fabric

illustrates a transitional stage towards microgranite. It is slightly miarolitic. The dominant feldspar is reddish-brown. In one of the hand specimens there is visible a grain of purple fluorite 1·5 mm. diameter.

Microscopic Observations—The most abundant constituent is clouded microperthite. Plagioclase (albite), as separate individuals, is present to the extent of only a few per cent. Most of the quartz is in coarse graphic arrangement with the microperthite but is also present as fine micrographic intergrowths. Biotite with X = light-brown; Y = Z = dark olive-green is present in minor quantity.

Of accessory minerals, magnetite and zircon are rare. Fluorite is comparatively abundant, usually intergrown with the biotite but also met with in grains up to 1 mm. by 0·8 mm. scattered elsewhere in the slide.

Rock [5791]

This is a leucocratic, aplitic, buff microgranite of general fine-grained nature but with some porphyritic dark quartz grains. It is from the south end of outcrop 20. It is finer-grained and contains less mica than the granite of other parts of this mass. In the microscope slide it is seen to contain grains of fluorite, not only associated with the biotite but as clear grains amongst the quartz and feldspar and embedded in the latter. Some of the quartz is in micrographic intergrowth with microperthite.

Rock [5787]

This is an aplitic microgranite from outcrop 18. It is very similar to [5786] as viewed in the hand-specimen, but is characterised by the dark appearance of the quartz grains.

Microscopic Observations—Clouded microperthite is abundant as coarse crystals; these contain a notable amount of plagioclase intergrown with it. On the other hand, there is a paucity of free plagioclase ($Ab_{96}An_4$) as compared with rock [5783]. A small amount of strongly pleochroic biotite is present: X = straw-yellow, Y = Z = very dark brown. The accessories are zircon, magnetite and fluorite.

OUTCROPS OF THE EAST SIDE OF THE MOUNT BOOTHBY RIDGE

This group is taken to comprise outcrops 7 to 9 and 12 to 16, representing a considerable area of granite, but mainly low-lying and inconspicuous occurrences. Those like 8 and 9 are so flat and unrelieved as to be easily overlooked even by an observer in the close vicinity. Outcrop 7 is a high rock of limited area. Numbers 15 and 16 are larger areas but are partly hidden by a thin covering of sandy regolith.

Petrography

Rock [5795]

Biotite granite from the foot of the Mount Boothby Range on the east side. This location is outcrop 14 just south of a dry dam, close to a boundary fence, some ¾ mile west of the south-east corner of P.L. 1577. From Tintinara Railway Station this lies about 15 miles on a west-by-north bearing. The rock is a medium-grained biotite-granite in which the quartz is somewhat smoky. The ferromagnesian constituent is more abundant than in rock [5783] of the Cambalapien outcrop.

Microscopic Observations—Microperthite is plentiful as individuals up to 6 mm. in length. Plagioclase, though in considerably less amount, is also a major constituent; it is in smaller, strongly zoned crystals up to 1·5 mm. in length, often in clustered arrangement. Optical measurements on selected examples of zoned crystals indicate an inner zone composition of $Ab_{70}An_{30}$ ranging to

$Ab_{85}An_{15}$ without. It was further estimated that their average composition approximates to $Ab_{83}An_{17}$ (oligoclase). A small scale development of a fine myrmeketic intergrowth with quartz is to be noted around some of the plagioclases.

Quartz, in large symmetrical grains, is next in abundance to the feldspars. Biotite, pleochroic from light yellow-brown, is present to the extent of about 5 or 6 per cent. There is also about 1% of a hornblende, pleochroic from light brownish-green to dark green. These ferromagnesian minerals are usually closely associated, but no reaction relation is indicated.

Accessory minerals are grains of ilmenitic black iron-ore occasionally partly leucoxenized: apatite in tiny rods; zircon in small crystals; also occasional tiny sphenes which are usually grouped in close association with the ferromagnesian minerals. There has been noted also one very small grain of fluorspar and a grain of calcite 0·5 mm. in length enclosed within an assemblage of biotites.

Rock [6045]

Biotite-hornblende-adamellite from Tor Rock (outcrop 7). In the hand-specimen this does not differ greatly from [6046], but the quartz is not so regularly distributed.

Microscopic Observations—The potash feldspar is observed to be mainly orthoclase but grades into microperthite. It is much altered in places. The plagioclase is zoned from $Ab_{70}An_{30}$ within to $Ab_{80}An_{20}$ without; a sericitic clouding is observed in some individuals. The biotite is much altered to chlorite. Hornblende is rare.

Bright, brown pleochroic sphene up to 1·8 mm. in length is commonly associated with the biotite. The accessories are black iron-ore, apatite, and zircon; all are rare. Occasional grains of yellow epidote have developed.

OUTCROPS IN THE NEIGHBOURHOOD OF ARMCHAIR ROCKS

To the west of Reedy Wells the track rises some 60 feet on to a low timbered platform from which rise granite tors and whalebacks. Judging by the extent of timbered country the granitic area in this region is quite considerable. At about 1 mile west of Reedy Wells there are some outcrops of unusual shape. One of these, weathered out to form a comfortable seat (see pl. xvii, fig. 2) suggested the name of Armchair Rocks for the locality. Another unusual erosion form is illustrated in pl. xvii, fig. 1.

About 400 yards further to the west-north-west are some high tors, one (pl. xviii, fig. 1) quite 30 feet in height. Within 2 miles west of Reedy Wells is the low face of granite shown in pl. xviii, fig. 2.

Petrography

Rock [5793]

Biotite-hornblende-adamellite from the eastern outcrop at Armchair Rock is medium to coarse-grained and macroscopically very like [5792], though somewhat coarser. In general appearance it bears a resemblance to [5783], but in this case the feldspar is all yellowish-buff. It presents an evenly mottled appearance, resulting from coarser feldspar-rich areas distributed among finer-grained aggregates richer in somewhat-smoky quartz and ferromagnesian minerals.

Microscopic Observations—The hypidiomorphic to allotriomorphic granular texture is modified by a glomeroporphyritic tendency of the quartz.

The larger and more abundant feldspar is a somewhat cloudy microperthite, present as individuals up to 8 mm. in length; the plagioclase constituent occurs as blebs and filaments about 0·03 mm. thick along intersecting planes. Plagioclase, which is always clear compared with the potash feldspar, also occurs in the

general body of the rock, as small strongly zoned, usually anhedral crystals; optical measurements show the range of composition to be from $Ab_{65}An_{35}$ in the case of the minor zone to $Ab_{89}\,An_{11}$ without. The average grade of this plagioclase is oligoclase about $Ab_{85}\,An_{15}$.

The ferromagnesian mineral is principally biotite, whose pleochroism is X = light brownish-yellow, Y = Z = very dark brown, almost opaque. There is a very little greenish hornblende. There is evidence that some at least of the biotite was developed at the expense of the amphibole.

Accessory minerals are zircon, apatite, black iron-ore, and rarely, sphene. There was observed only one doubtful grain of fluorspar.

A chemical analysis appears in the table on page 267.

The Norm is as follows:

Quartz	32·28	Magnetite	0·93
Orthoclase	29·47	Ilmenite	0·61
Albite	28·82	Apatite	0·14
Anorthite	2·78	Calcite	0·60
Corundum	1·43	Fluorite	0·31
Hypersthene	2·58	H_2O	0·32
		Total	100·27

The C.I.P.W. classification is: I. 4. 2. 3.

As the slide area available was small compared with the grain-size, an approximate value only was obtained for the Mode, namely, as follows: quartz 37·1%, microperthite 33·6%, plagioclase 25·0%, biotite and accessories 4·3%. The values obtained are sufficient to indicate that it is a potash-soda granite coming within the adamellite sub-group.

ROCK [5782]

Biotite-hornblende-adamellite from the northern outcrop at the Armchair Rocks locality. It is a medium-grained granite generally similar to [5793], though more even in texture. Here, however, the small plagioclases are distinguishable owing to their white appearance.

Microscopic Observations—The slide reveals the presence of a larger proportion of amphibole to biotite than in [5793]; also a greater abundance of apatite and zircon. The zoned plagioclases were found to range between $Ab_{70}\,An_{30}$ within to $Ab_{89}\,An_{11}$ without. The more anorthitic central areas show a tendency to clouding, while the albitic outer zones are always quite fresh.

ROCK [5788]

Biotite-hornblende-adamellite is an example of the normal type of granite of outcrop 11. It is a medium to fine, even-grained rock in which the slightly-smoky quartz shows up well among the off-white to faintly buff feldspar. In the hand-specimen it resembles [5788].

Microscopically examined, this rock was found to have no special features not met with in other granites of the neighbourhood. The quantity of hornblende is perhaps greater than usual. The biotite is observed to have been derived from the hornblende. Accessories are apatite, zircon and ilmenitic black iron-ore partly leucoxenized.

ROCK [5794]

Biotite-hornblende-adamellite, from a large tor of the western extensions of outcrop 10, is a medium- to coarse-grained rock bearing a close resemblance to [5793].

Microscopic Observations—But for the presence of more hornblende, the slide presents very similar features to that of [5793]. The hornblende is strongly pleochroic: X = light brownish-green, Y = Z = dark green; it usually occurs in association with the biotite. The quartz exhibits cracking and undulatory extinction. Microcline-perthite is present. The plagioclase is strongly zoned, ranging from $Ab_{63}\,An_{37}$ to $Ab_{94}\,An_{6}$, in which the albite zone is very narrow.

Accessories comprise an unusually large amount of both apatite and sphene, some black iron-ore and leucoxene and a little zircon.

A Rosiwal modal measurement gave quartz 34·0%, microperthite 35·2%, plagioclase 26·6%, biotite 3·2%, hornblende 0·6%, and accessories 0·4%.

Rock [5794A]

Potash-soda-leucogranite also from the western part of outcrop 10, is a coarser rock than [5794]. The quartzes are distinctly smoky and the biotites notable; also pinkish potash feldspar of larger size and small whitish plagioclases are a feature.

Microscopic Observations—Coarse microcline and microcline-perthite are a feature, and they occasionally contain graphically intergrown quartz. Orthoclases are present of rather larger size than usually appear in these granites. There is evidence that large, first-formed, orthoclases were subsequently affected by late-magmatic mother liquors resulting in the introduction of albite and quartz. The plagioclase is rather free from zoning and has optical characters of an albite ($Ab_{94}\,An_{6}$).

The ferromagnesian mineral is mainly biotite, but there is also a very small quantity of greenish hornblende. There are several small radial patches of a chloritic substance evidently representing an altered ferromagnesian mineral. Accessory minerals noted are black iron-ore, tiny zircons, rods of apatite and one small grain of greenish fluorite.

OUTCROPS IN THE VICINITY OF TOLMER'S ROCK

Included in this section are those numbered 1 to 6 on the map (page 265). An area of nearly half-a-mile around Tolmer's Rock is a feature of the landscape for, (*a*) it is clothed in a growth of relatively high eucalypts which contrast with the low banksia scrub of the surrounding sandy plains; (*b*) it is elevated somewhat above the surrounding country. The summit of the highest granite mass is 125 feet above the ground surface at Reedy Wells.

Granite appears at intervals over an area about 300 yards in diameter around Tolmer's Rock (outcrop 1). It reappears as a small face to the west at number 4 and as a long ridge, numbers 2 and 3, located to the east-north-east. Rock [5792] of number 1 is obviously more biotitic than that from Cambalapien, and it appears to weather somewhat more readily. One tor has a cavern excavated in it to a depth of about 10 feet, and there a large, partly assimilated xenolith [6044] was observed.

Granite from the above-mentioned half-mile long, S.W. to N.E. trending ridge which includes outcrops 2 and 3, is very like in appearance to that occurring at Murray Bridge. The width of this ridge is only about 200 yards. There is, there, in addition to the normal rock [6048], some intersecting veins of aplitic microgranite [6047], and an occasional pegmatitic schliere.

Rock [6046] is from the Monolith (No. 5), which is a small isolated mass rising out of an extensive flat sandy area occupied by low scrub.

Petrography

Rock [5792]

Hornblende-biotite-adamellite from Tolmer's Rock (outcrop 1) is a coarse-grained, pinkish granite in which can be seen light grey quartz, light pink feldspar, yellowish-grey plagioclase and minor amounts of biotite and hornblende.

Microscopic Observations—The texture is coarse granitic. The quartz, in clear anhedral crystals, tends to be distributed as glomeroporphyritic aggregates. Liquid and gas inclusions are aligned along defined tracks, and some crystals show slight undulose extinction.

Microperthite occurs in large anhedral individuals up to 8 mm. long; it is but little affected by secondary clouding. Antiperthite, though rare, is recorded in the slide. Plagioclase is present as abundant subhedral crystals of smaller size than the potash feldspar; individuals reach 3 to 4 mm. in length. Slight zoning is usually evidenced; in one case a range from $Ab_{77}\,An_{23}$ within to $Ab_{85}\,An_{15}$ without was observed. Making allowance for the respective width of zones, it is estimated that the average composition of this zoned crystal would be about $Ab_{82}\,An_{18}$.

The ferromagnesian minerals are biotite and hornblende; they are distinctly more abundant than in the Cambalapien rocks. The biotite is pleochroic: X = light brown, Y = Z = very dark brown, almost opaque. The flakes are often clustered together into aggregates. Alteration to pleochroic green chlorite is to be seen. Hornblende with pleochroism, X = yellow-brown, Y = very dark brown, Z = dark green, is not so abundant as the biotite; the crystals are quite fresh, subhedral in form and occur up to 0·8 mm. in length.

Accessories are rather abundant. Light-brown sphene often appears in lozenge-shaped twinned crystals up to 0·5 mm. in length. Small embedded apatites and grey zircons are common; grains of black iron-ore are frequently associated with the biotite and hornblende. No fluorite has been observed in slides examined.

A chemical analysis of this rock appears in the table on page 267. From it the Norm as stated below has been computed. A Rosiwal measurement of the Mode, made on two large slides, is given below; the quartz in this by comparison with the Norm appears to be low; this may be so, for there is a tendency when making slides of this rock to include more of the finer-grained quartz-rich areas and to loose some of the feldspar-rich portions.

Mode	
Quartz - -	24·8
Perthite - -	39·7
Plagioclase -	28·4
Biotite - -	4·0
Hornblende -	2·2
Magnetite - -	0·3
Sphene - -	0·3
Apatite - -	0·2
Zircon - -	0·1
Total	100·0

Norm	
Quartz - -	28·08
Orthoclase -	28·36
Albite - -	29·87
Anorthite - -	6·67
Corundum -	0·61
Hypersthene -	2·91
Magnetite -	1·62
Ilmenite - -	0·76
Apatite - -	0·34
Fluorite - -	0·16
Calcite - -	0·31
H_2O - -	0·46
	100·15

The C.I.P.W. classification is: I. 3. 2 3.

Rock [6044]

This is a highly transfused portion of a large xenolith out of the adamellite [5792] of Tolmer's Rock. It is somewhat darker coloured than the enclosing rock, with a fine-grained base through which are scattered irregular porphyritic crystals of quartz, feldspar, hornblende and biotite. In the centre of the xenolith there remain less-altered relics of hornfels, which suggest that the original rock, later to be engulfed as a xenolith, was probably of a slaty nature.

Microscopic Observations—The fine-grained (about 0·2 mm.) base is an equigranular aggregate of quartz and feldspar with subordinate biotite and hornblende; embedded therein are occasional larger quartzes and feldspars, the latter hypidiomorphic in form. As would be expected, the minerals of this transfused xenolith are similar in composition to those of the embedding granite.

The quartz is clear with occasional patches of dusty inclusions. The larger plagioclase crystals are up to 2 mm. in length; they are strongly and sharply zoned into two parts, having the composition $Ab_{55}\,An_{45}$ (andesine) within and $Ab_{80}\,An_{20}$ (oligoclase) without. Evidently when the process was arrested the andesine was in progress of being made over to the oligoclase by sodic magmatic liquors. Also there are present porphyritic (up to 4 mm.), slightly cloudy microperthites.

Occasional very fine-grained, granophyric intergrowths of quartz and feldspar are to be seen. Biotite and hornblende, the former preponderating, are similar in nature to those of the granite. Accessories, apatite, magnetite, sphene and zircon are rare except the first mentioned.

A Rosiwal measurement indicates the percentage composition of the Mode to be approximately as follows:

Quartz - -	38·6	Biotite - -	8·1
Microperthite -	36·7	Hornblende -	3·3
Plagioclase -	18·1	Apatite - -	0·2

Rock [6048]

This is a hornblende-biotite-adamellite from outcrop 2. In appearance it is very similar to [5792], though coarser grained. The ferromagnesian minerals are less abundant, while the quartz and feldspars show a greater tendency to form clustered aggregates.

Microscopic Observations—This is a hypidiomorphic granular rock differing from [5792] chiefly in its coarser grain and smaller amounts of ferromagnesian minerals. The plagioclase is rather more strongly zoned, ranging from $Ab_{73}An_{27}$ within to $Ab_{90}An_{10}$ without. An estimate of its average composition is $Ab_{85}An_{15}$ (oligoclase). It is twinned on the albite, pericline and Carlsbad laws. Some crystals show slight secondary alteration of the inner zone with the development of calcite, sericite and rarely, epidote.

Accessories are sphene (one crystal measuring 1·7 mm. x 1 mm.), magnetite, apatite, zircon and a little fluorite.

Rosiwal measurements, based on three large slides, gave the Mode as:

Quartz - -	35·7	Biotite - -	3·7
Microperthite -	31·9	Hornblende -	0·9
Plagioclase -	27·3	Accessories -	0·5

As the feldspars are fairly uniformly distributed it is believed that the above figures are relatively significant for them. In the case of the quartz, however, its distribution in clustered aggregates probably vitiates the result; the quantity ranged from 29% to 41% in the several slides which, however, may present an unduly high proportion of quartz-rich sections of the rock.

Rock [6042]

Aplitic micro-adamellite from outcrop 2 occurs as a 3-feet wide dyke in the main mass of the hornblende-biotite-adamellite [6048]. It is fine-grained, yellowish-brown, and composed of light brown feldspar and quartz, plus a minute quantity of biotite.

Microscopic Observations—It differs from the parent rock mainly in grain-size and poverty in ferromagnesian minerals. The average grain-size is about 0·5 mm. Orthoclase is present in irregular anhedral crystals somewhat larger than the average grain-size. The plagioclase, which is anhedral to subhedral, has the composition $Ab_{85}An_{15}$ and is not zoned. Biotite is present only in accessory proportions. Other accessories which include black iron-ore, zircon, and apatite are very rare. A little epidote and some sericite is present as a change product in the plagioclase.

Rock [6046]

Biotite-hornblende-adamellite from the Monolith (outcrop 5) is finer grained and greyer than [5792]. Quartz is more abundant. The two feldspars appear to be present in nearly equal proportions. Distribution of the minerals is much more even than in the case of [5792].

Microscopic Observations—The orthoclase, some of it microperthitic but containing a very small proportion of plagioclase, tends to form larger crystals (usually about 3 or 4 mm.) than the plagioclase individuals which are commonly only about 1·5 mm. in length.

The plagioclase intergrown with the orthoclase occurs not only in the usual irregular bands and patches, but also as a very fine, regular, parallel intergrowth which, at first sight, may be taken for the albite twinning of plagioclase. The plagioclases are usually not zoned in the case of the large individuals, but the smaller ones are zoned. Unzoned crystals have a composition about $Ab_{80}An_{20}$ (oligoclase).

Biotite is plentiful but in places has been altered to a pleochroic, green chlorite answering to penninite. Hornblende is in much smaller quantity than in [5792]. Accessories are not abundant; they comprise light brown sphene, magnetite, apatite and zircon.

A Rosiwal measurement gave the Mode as: quartz 38·0%, orthoclase and perthite 31·8%, plagioclase 26·5%, biotite, etc., 3·8%.

CONCLUSIONS

The chemical composition of three type granites from the Tintinara district are given in Table A, and with them are collected analyses of several of the more typical key granites from other areas of the South-East.

In Table B are set out the average composition of some combinations of the granites of Table A, and in addition, an analysis of the Dergholm granite of Western Victoria and a tordrillite from Nevada. Column I is the average of the three more leucocratic of our South-Eastern potash-soda granites. Column II is the mean of three less leucocratic examples, and which are, in fact, probably more normal for the magma. Column III is the mean of both the above averages, and so must be a close approximation to the magma typical of the batholyth as a whole. Column IV is a further combination representing a somewhat more basic variant, namely the mean of the composition of the granite of Tolmer's Rock and that of Column III which is the average of all the others in Table A. This latter combination should illustrate a possible phase of the batholythic magma and is

observed to correspond rather closely to the composition of the Dergholm granite stated in Column V.

TABLE B

	I	II	III	IV	V	VI
SiO_2	76·25	73·84	75·04	73·16	74·37	74·30
Al_2O_3	12·60	13·37	12·98	13·51	13·01	13·29
Fe_2O_3	0·48	0·64	0·56	0·84	0·84	1·15
FeO	0·85	1·58	1·21	1·57	1·12	0·10
MnO	0·04	0·03	0·04	0·05	0·17	trace
MgO	0·06	0·16	0·11	0·22	0·05	0·09
CaO	0·72	1·01	0·91	1·36	1·44	0·85
Na_2O	3·61	3·61	3·61	3·58	3·17	3·75
K_2O	4·86	4·88	4·87	4·83	4·56	4·83
H_2O+	0·32	0·35	0·34	0·36	0·52	0·50
H_2O-	0·10	0·08	0·09	0·09	0·15	0·91
TiO_2	0·11	0·23	0·17	0·27	0·25	0·20
P_2O_5	0·02	0·06	0·04	0·08	trace	0·07
ZrO_2	0·01	0·01	0·01	0·02	nil	—
BaO	0·03	0·04	0·04	0·03	nil	nil
CO_2	0·05	0·15	0·10	0·13	trace	nil
F	0·13	0·11	0·12	0·11	—	—
Cl	—	0·02	0·01	0·04	trace	—
S	0·01	0·02	0·01	0·01	0·04	0·03
	100·25	100·19	100·26	100·26	99·69	100·07
Less O for Cl, F, and S	0·06	0·05	0·05	0·06	0·01	0·01
Total	100·19	100·14	100·21	100·20	99·68	100·06

I. The average composition of three leucogranites I, II, and III of Table A (page 266).

II. The average composition of the three potash-soda rocks IV, V and VI of Table A.

III. The mean of columns I and II of this table thus representing the average composition of six characteristic leucocratic potash-soda granites of the Upper South Eastern District of South Australia.

IV. A mean composition resulting from averaging the values in column III above and column VII of Table A (granite from Tolmer's Rock), which latter represents a slightly more femic phase of these granites.

V. The chemical composition of the Dergholm (Western Victoria) granite. This analysis was made by F. F. Field, of the Victorian Department of Mines, for Mr. D. J. Mahony. Field's analyses record also the following: LiO_2 a trace; CoO, NiO and Cr_2O_3 all nil.

VI. Tordrillite from Sweetwater, Nevada. Analyst: G. Steiger. Described by J. E. Spurr, U.S.G.S. Bulletin 228 (1904).

The Dergholm granite, in addition to chemical affinity with the neighbouring South Australian granites, is of similar appearance and mineral constitution. The heavy minerals of the Dergholm granite (1) are also in reasonable agreement with those of the granites of South-Eastern South Australia.

Professor E. W. Skeats, in reviewing (4) the granites of Victoria, has stated: "The Dergholm granite in the Western District is an acid variety similar to the granites of the Murray Bridge district and may be Pre-Cambrian."

Finally, as there is no evidence contrary to this conclusion, it may be accepted that the Dergholm granite is part of the batholyth which, extending from Murray Bridge, occupies so much of the South-East of this State.

Near Hamilton in Western Victoria there is an ancient quartz-porphyry underlying Miocene sediments; this closely resembles some phases of the rock of the Mount Monster (near Keith, South Australia) outcrops. It may be a further appearance within Victoria of the Murray Bridge magma.

Whether the latter was intruded in Pre-Cambrian times has yet to be proved, for there has been advanced no evidence definitely precluding the consideration of late-Cambrian as the period of its intrusion.

SUMMARY

An account of the distribution of ourcrops and nature of the granites of the Tintinara District is given. This concludes a detailed survey of the granites of South-Eastern South Australia.

Over a very wide area, apparently extending into Victoria, there is demonstrated the existence of a large-scale granite batholyth, recognised until recently as existing only in the region adjacent to Murray Bridge.

Fluorite as an accessory primary constituent occurs in the granite of many of these outcrops that are of the nature of leucogranites. Where hornblende makes its appearance, fluorite is usually absent. Accessory calcite also has been observed in clear grains which appear to be a primary constituent.

ACKNOWLEDGMENTS

Our thanks are due to Mr. L. H. Mincham and Mr. H. E. E. Brock for assistance in the field. We are indebted to Dr. Frank Stillwell for locating and communicating a chemical analysis of the Dergholm granite.

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DESCRIPTION OF PLATES

Plate XVI

Fig. 1—Granite masses outcropping at Tolmer's Rock. The figures are L. H. Mincham and H. E. E. Brock. Photo by D. Mawson. Fig. 2—Outcropping granite masses of the Armchair Rock group. Photo by D. Mawson.

Plate XVII

Fig. 1—A granite monolith of peculiar form developed by weathering processes from the neighbourhood of Armchair Rock. Photo by D. Mawson. Fig. 2—Armchair Rock, located one mile west of Reedy Wells. The northern side is protected from weathering by superficial case-hardening. On the shaded side, weathering and erosion have been active, hollowing it out as shown. The figure is L. H. Mincham. Photo by D. Mawson.

Plate XVIII

Fig. 1—A granite mass situated several hundred yards to the north-west of Armchair Rock. Photo by D. Mawson. Fig. 2—A whaleback outcrop (Car Rocks) located west of Armchair Rock. Photo by D. Mawson. Fig. 3—Granite outcrops in the vicinity of Tolmer's Rock. Photo by D. Mawson. Fig. 4—Tor Rock (outcrop 7). Photo by E. R. Segnit.

Fig. 1

Fig. 2

Fig. 1

Fig. 2

Fig. 2

Fig. 4

Fig. 1

Fig. 3

SOME ASPECTS OF THE GEOMORPHOLOGY OF PORTION OF THE MOUNT LOFTY RANGES

BY R. C. SPRIGG (READ 13 SEPTEMBER 1945)

Summary

This contribution to the physiography and development of the Mount Lofty Ranges is the outcome of extensive geological reconnaissance mapping along the western slopes of the range. Certain of its more essential features formed the physiographic section of a thesis dealing with geological investigations carried out in the western Mount Lofty foothills. The scope of the work has since been expanded considerably.

SOME ASPECTS OF THE GEOMORPHOLOGY OF PORTION OF THE MOUNT LOFTY RANGES

By R. C. Sprigg

[Read 13 Sept. 1945]

Plates XIX and XX

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INTRODUCTION

This contribution to the physiography and development of the Mount Lofty Ranges is the outcome of extensive geological reconnaissance mapping along the western slopes of the range. Certain of its more essential features formed the physiographic section of a thesis dealing with geological investigations carried out in the western Mount Lofty foothills.[1] The scope of the work has since been expanded considerably.

The paper has been divided into two sections. The first portion consists of land-form analysis. An attempt has been made to establish more definitely the

(1) Sprigg, R. C., Thesis for Degree of Master of Science, Adelaide University.

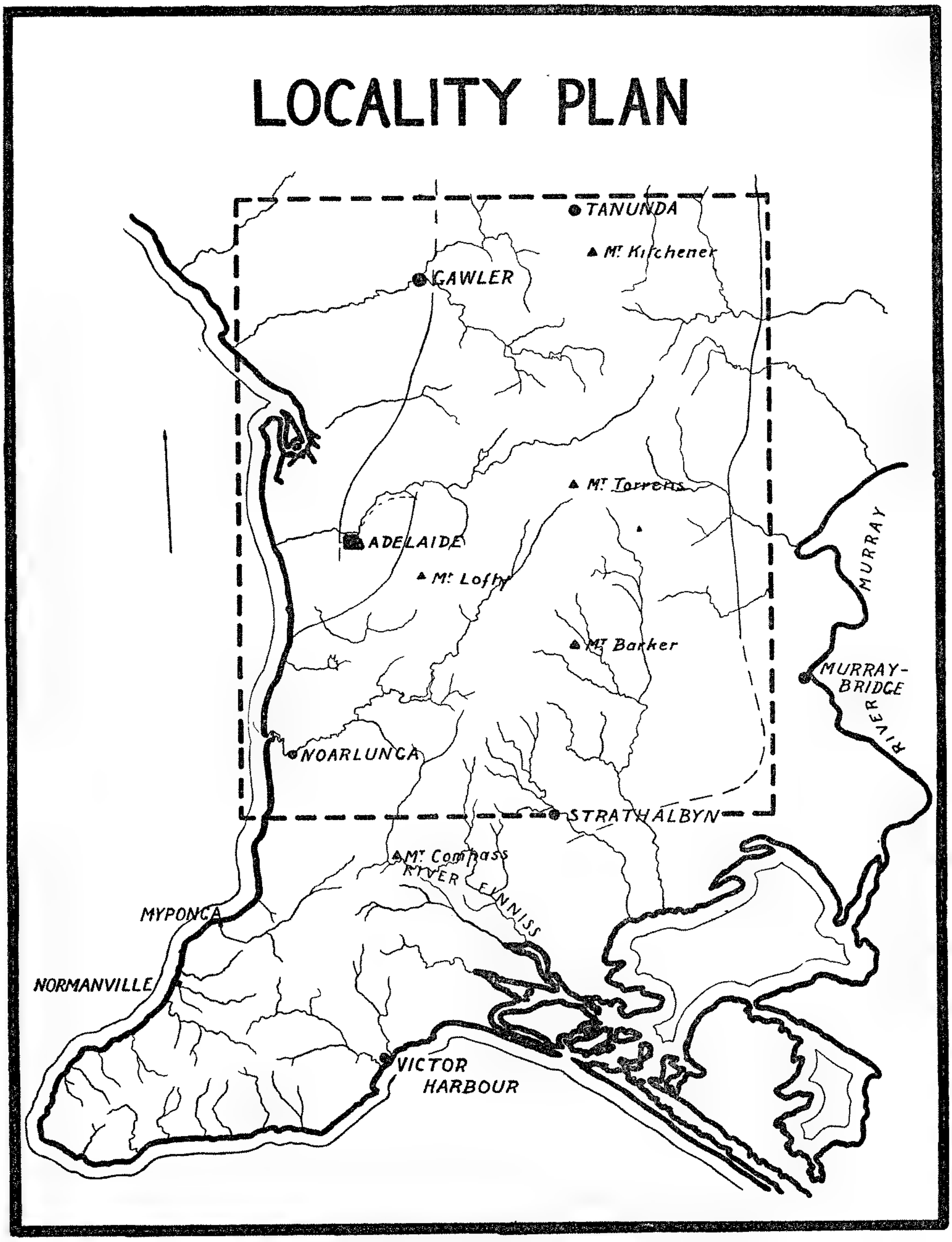

Fig 1 Locality Plan, showing portion of the Mount Lofty "Horst" Range.

fracture-pattern of the fault blocks constituting the Mount Lofty Horst and their relative degrees of movement; to describe the topography of the early Tertiary erosion surface and its relationship to the present-day land forms.

Part II is a description of the hydrology of portion of the area, with special reference to the history of some of the streams of the western escarpment.

THE AREA

The area investigated comprises a rectangular strip across the Mount Lofty Ranges, extending from Angaston in the north to McLaren Vale in the south. To the west it is bordered by St. Vincent Gulf, and to east by the eastern escarpment fault of the Mount Lofty Ranges. In the direction of longitude and latitude the area extends 50 and 40 miles respectively.

GEOMORPHOLOGY

The Mount Lofty Ranges form part of a major meridional "horst" region bounded on the west by the St. Vincent Gulf-Adelaide Plains Senkungsfeld, and on the east by the Murravian Basin.

The conception of the Gulf and Range regions of the axial area of South Australia as a fault-block system we owe to Dr. W. N. Benson (1911). This theory has been developed and accepted by other workers, notably Dr. C. Fenner (1930 and 1931), who produced a major work on the subject.

The "range" region consists of a number of fault blocks, elevated differentially above the bordering alluvial plains. The principal fault escarpments are well defined.

In early Tertiary times much of South Australia had been reduced to a "base surface" (term preferred to peneplain—see Horton, 1945). The land surface was "old and fully dissected." This erosion surface was then buried by Tertiary lacustrine and marine deposits (the overmass sediments). Block faulting began later in the Tertiary Period. Differential movements of the various fault blocks, particularly those near Adelaide, resulted in warping and tilting. The new cycle of erosion which now began has removed the bulk of the overmass sediments as well as much of the early Tertiary erosion surface.

Topography in the vicinity of the major fault escarpments is "young, well dissected." Dissection has proceeded more rapidly along the western aspect of the range by reason of greater rainfall (relative "rainshadow" to the east) and higher gradients. In the central (plateau) area, mature characters are more in evidence. The topography there is "young, little dissected," and, therefore, strongly resembles the original erosion surface. In such regions stream gradients and drainage densities are lower than at the escarpments.

Where stream erosion is powerful, more particularly in the western regions, gorges, waterfalls and rapids are prominent features.

PART I. LAND FORM ANALYSIS FROM TOPOGRAPHICAL MAPS

Sufficient of the old erosion surface still remains to allow a satisfactory reconstruction of the block-fault pattern and the relations of the various blocks. To aid in such reconstruction a special topographic map was prepared by the author and submitted as part of the original thesis. In it spot altitudes (selected from military survey maps) were used. The levels selected were all "high spots," and these formed the basis of a contour plan in which erosion by minor streams was disregarded.

Since the thesis was submitted for examination the author has found that other improved techniques have been devised. These are described in the following pages, and the results of their application to the area in question are incorporated in this paper.

In a paper presented to the Royal Society of New South Wales, Mr. W. H. Maze (1944) described several techniques of land-form analysis which have been developed in recent years. He examined the methods, made slight modifications

and applied them to areas in New South Wales, for which topographic maps prepared by the Military Survey of Australia are available.

These maps have a scale of one inch to one mile with a contour interval of 50 feet. More recent editions are gridded into areas 1,000 yards square and so,

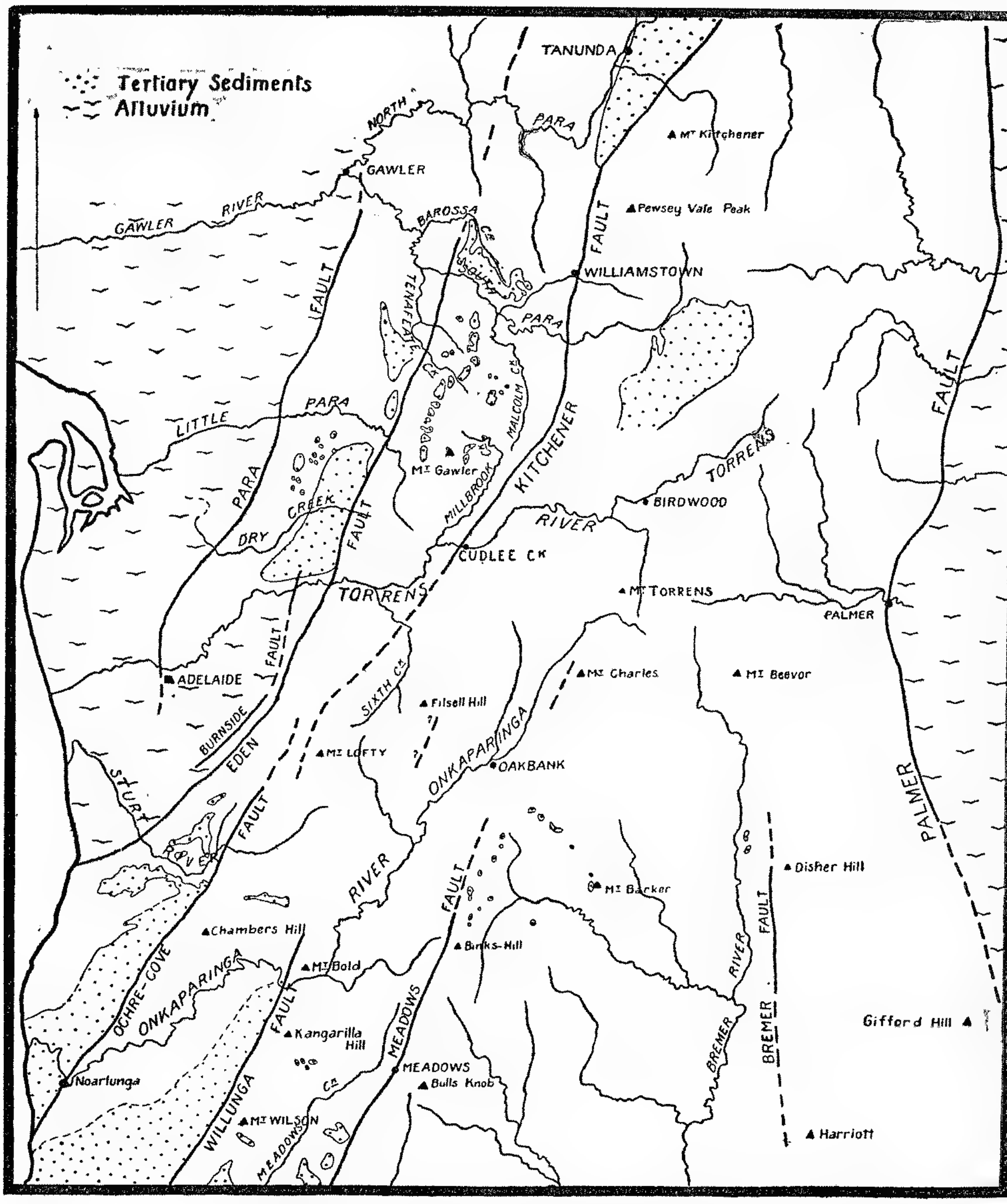

Fig. 2 Key plan to the Central Mount Lofty Ranges

in Maze's words, "readily present small units suitable for any statistical methods of relief analysis." The accuracy of the maps has been set out by F. A. Vance (1940). It is not suitable for the determination of minor features in the landscape, but it is sufficient for the preparation of generalized maps for use in the reconstruction of old land forms and erosion surfaces now in the course of dissection.

The three principal methods of analysis applied by Maze are closely followed, with certain small modifications, in this paper. The reader is referred to that author's paper if further details are required.

All three methods are based upon data obtainable from topographic maps. In South Australia the military survey maps are the only ones which are satisfactory, being gridded into 1,000 yard squares. From these maps a special base plan is prepared showing the grid squares for the area under analysis. "In each square the height of the highest point in the corresponding square of the topographic map" is recorded. "The value of the height of the highest point in each square" is plotted "as the height shown by the contour encircling the highest area in each square and reckoned as having a value up to 50 feet above that height" (Maze).

The size of the mesh of readings is very significant. With this in mind Maze tested a coarser and a finer mesh of readings. A mesh of 4,000 yards was found to give insufficient information in some areas, while one of 250 yards "was found in sample areas, to give essentially the same results as the 1,000 yards grid squares." The military grid of 1,000 yards is, therefore, regarded as sufficiently detailed in the case of major land-form surfaces.

This plan of the "high-point" values of the area to be analysed is all that is required for the three methods described below. For the central Mount Lofty Ranges area selected by the author almost 5,000 values for "high points" were recorded.

Altimetric Frequency Curves

By this method the values of the "high-points" are listed and arranged to give the frequency of occurrence of each height. From such frequencies a frequency curve has been constructed, showing the altitudinal distribution of such

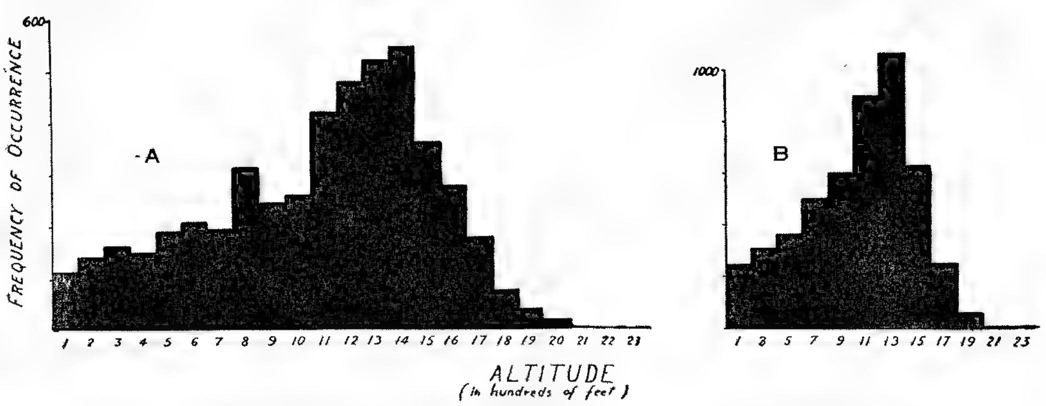

Fig. 3 Altimetric frequency curves for the Central Mount Lofty Ranges

"high-points" over the central Mount Lofty Ranges. In fig. 3A, the frequencies have been plotted against altitudinal intervals of 50 feet. However, as Maze points out, the grouping of the frequencies for an additional range of 50 feet is unsatisfactory when dealing with any erosional surface. In the Adelaide region block "warping" and "tilting" has introduced an additional factor which renders such grouping of little value. An altitudinal interval of 200 feet (fig. 3B) is therefore more satisfactory, although both curves give essentially the same results.

From a study of these two diagrams it is immediately apparent that there are broad areas ranging between 1,100 and 1,600 feet with maximum development between 1,400 and 1,500 feet. Slightly more than 40% of the total readings fall into the former altitudinal range which constitutes approximately 22% of the

maximum altitude recorded for the area. This suggests the presence of an extensive tract of erosion surface within the 1,100-1,600 foot range.

The even distribution of the altitudinal frequencies suggests that tilting and warping of the ancient erosion surface has been general. To examine further such possibilities, a new technique of displaying the altimetric frequency data has been introduced by the author. It is intended to display the altitude frequencies in such a manner as to give a "summary profile" for the whole area. Altitude frequencies have been totalled successively to give a summation curve when plotted against height above sea level. The height above sea level has been plotted against the vertical axis in altitudinal intervals of 50 feet.

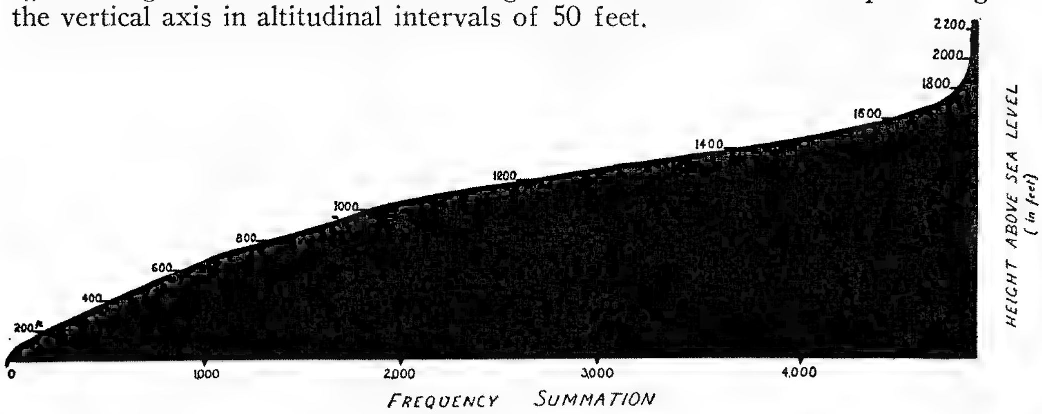

Fig. 4 Summation Profile

The diagram (fig. 4) produced in this manner shows a very smooth disposition of altitude frequencies. There are no abrupt interruptions in the summary profile to indicate large areas of horizontally disposed erosional surfaces. However, there is the marked flattening of the curve between 1,100 and 1,600 feet which is not likely to be wholly fortuitous, and warrants the deduction that the old erosion surface is most widely preserved within this range. That the flattening of the curve is not as marked as might have been expected from our conception of the original erosion surface is not difficult to explain. The degree of perfection of the original peneplain surface (Early Tertiary) and the extent of deeper (modern) stream dissection have a considerable effect on the resultant altimetric frequency curves. Also warping of block surfaces serves to mask further the distribution of high level erosion surfaces. This block tilt and warping will be discussed below.

Strip "High-Point" Profiles

The second method used in this paper consists in the drawing up of what Maze calls "strip 'high-point' profiles." These are constructed by selecting the highest point from a strip 3,000 yards wide (*i.e.*, from three adjacent grid-squares) at 1,000 yards intervals along the line of section. The separate profiles represent strips 10,000 yards apart from centre to centre. Such a summary of high-point elevations covers 30% of the total area, and by eliminating recent minor erosional features emphasises major erosional surfaces and prominent structural features.

Nine strip profiles have been prepared for the Mount Lofty area, and the approximate location of the centres of each strip is indicated in fig. 5.

Profile A.A'.: Two, or possibly three, erosional surfaces and a surface of accumulation are indicated. The surface of aggradation (westernmost) is that of coalesced alluvial outwash fans at the eastern margin of the Adelaide Plains. Of the two major erosion surfaces the lower one, which occurs between 500 and

800 feet, is complex. There is evidence that it can be subdivided to correspond with the northern extensions of the differentially raised Para and Mount Gawler fault blocks. The downward dip beyond the relatively flat area to the east on this

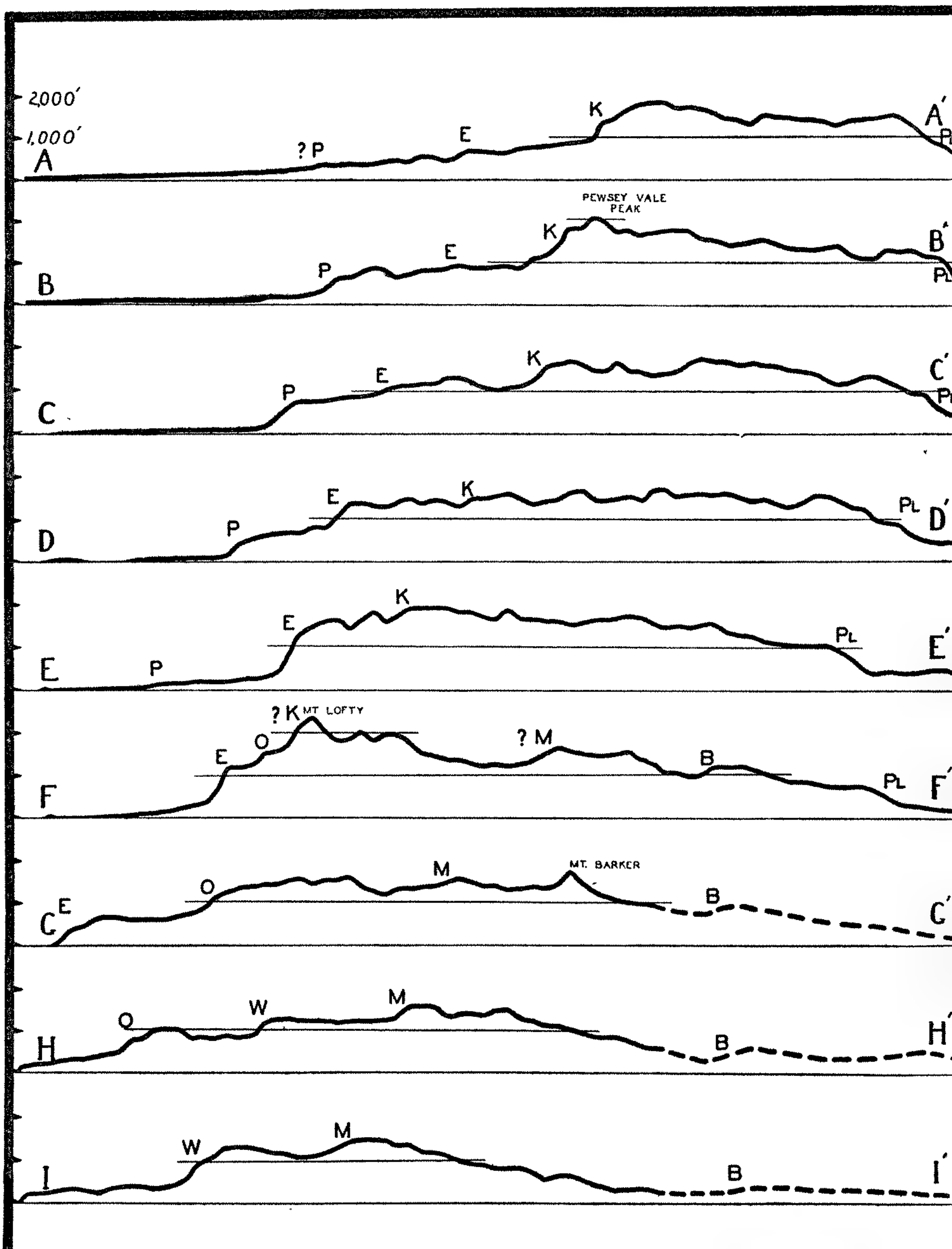

Fig. 5 Strip "high-point" profiles for the Central Mount Lofty Ranges

section probably marks the approximate location of the Eden fault (E). The Para fault (P) marks the western boundary of the lower erosional surface. The combined surface presented is in part the result of recent erosion in soft over-

mass (Tertiary) sediments. These sediments overlie the early Tertiary "peneplain" surface which is responsible for so much of the flat sky-line scenery to be seen in the Mount Lofty Ranges. Remnants of this fossil erosion surface "outcrop" on the western aspect of this section.

The higher erosional surface lies between 1,400 and 1,800 feet and constitutes a well-defined plateau delineated on its western and eastern margins by the Kitchener (K) and Palmer (Pl) faults respectively. This major fault block is tilted to the east.

Profile B.B′.: In general outline this profile is similar to Profile A.A′. The Para escarpment fault is now clearly defined. Pewsey Vale Peak (2,064 feet), the high point on the profile, is probably a monadnock "inherited" by the present erosion cycle.

Profile C.C′.: Save that the Para (P) and Eden (E) faults are more prominent, profile C.C′. closely resembles the two above.

Profile D.D′.: Although the relationships between the various surfaces of the profile are still much the same, the relative importance of the various fault escarpments has altered considerably. The Eden fault is rapidly becoming the most prominent, while the Kitchener fault is scarcely recognisable. Little or no eastward block tilting can be recognised between the Eden and Palmer faults. The average elevation of the major erosion surface is approximately 1,500 feet. Only small areas of overmass (Tertiary) sediments remain on the area represented by this profile.

Profile E.E′.: The Eden block fault in this section is the principal west escarpment fault. The downthrow of the Para block relative to the adjoining Gawler block exceeds 1,000 feet. The Para block surface is only 200-300 feet above sea level. There is no evidence of east tilt, although it may be masked by remnants of Tertiary Sedimentary series and outwash accumulations. Within the plateau area the profile does not exhibit major breaks. The Kitchener fault scarp is just recognisable and the eastern scarp is well defined. Mount Torrens appears as an "inherited" monadnock.

Profile F.F′.: The Para block (and the Burnside splinter block) are buried beneath alluvial accumulation within the Adelaide Plains. The Eden fault controls the abrupt western escarpment. A step-like arrangement of sub-horizontal surfaces before Mount Lofty suggests two additional block faults parallel to the Eden fault. These may be continuations of the Ochre Cove fault (O) (on the west) and the Kitchener fault (K).

Mount Lofty (2384 ft.) is probably another "inherited" monadnock.

Beyond Mount Cary the profile falls away in a manner which suggests further faulting, but there is insufficient evidence on hand to make a decision on this. A little to the west of Murdoch's Hill a low retreating escarpment marks the possible northern continuation of the Meadows fault. Assuming that this block fault is continuous here, the block to the east is tilted eastwards towards the Bremer (B) fault and block. The Bremer fault block dips east and is defined on its eastern border by the Palmer fault. The erosion surfaces of the Meadows and Bremer faults are not deeply dissected.

Profile G.G.[2]: Three erosion surfaces are plainly visible within the profile. They are defined on their western borders by the Eden fault (which has curved

(2) The Military Survey Maps for the south-eastern corner of the area have not been produced up to the time of writing. For completeness, an attempt has been made to overcome the deficiency; sketch profiles have been compiled from the little information at present available concerning details of the topography of the areas in question and added to eastern portions of Profiles G.G. to I.I., inclusive.

westward, out under the sea), the Ochre Cove fault and the Bremer fault respectively. The Eden-Moana block erosion surface is covered by a thin veneer of Early Tertiary sediments (Sprigg 1942). The erosion surface is remarkably horizontal in east-west section.

The profile for the central erosion surface does not exhibit the significant characteristics of pronounced block faulting. However, from field evidence and from the results of other methods of analysis (see below), it is almost certain that two other block faults occur within this segment of the profile. The westernmost of these two faults has a very small downthrow to the west and is the northern continuation of the Willunga scarp fault. The Willunga fault block, like the adjoining Clarendon-Ochre Cove, Eden and Meadows fault blocks, is tilted down to the south. Its pivot or hinge line is situated somewhere in the vicinity of this profile section line. For this reason its confining faults are difficult to distinguish. The more easterly of the two faults referred to is the western escarpment fault of the Meadows block. It is just recognisable on the profile, and differential movement along it has produced only a low scarp. The erosion surface is tilted down to the east. Mount Barker stands out strongly as a pronounced monadnock. It has been inherited from the earlier erosion cycle.

The third erosion surface has been drawn in sketchily from sketchy survey data. The Bremer fault (Dickinson 1942) marks the western limits of the Bremer block. The escarpment formed is low. To the east the block merges with the Murray Plains and the profile surface becomes one of aggradation.

Profile H. H′.: In most respects this profile is similar to the last one. The Eden fault has disappeared beneath the sea. The Ochre Cove, Willunga and Meadows fault escarpments are all prominent. The erosion surfaces of the Clarendon-Ochre Cove and Willunga blocks have not been tilted down very significantly to the east, although overmass sediments may have masked such an effect. The Bremer block and escarpment fault are still recognisable.

Profile I. I′.: The various blocks and their erosion surfaces bear similar relations to those as in profile H. H′. The Eden block is not represented in the profile as the Ochre Cove fault has curved out under the sea. The Willunga fault now forms the main escarpment. The Willunga block erosion surface is tilted down to the east.

Reconstructed or Generalized Contours

An improved method for reconstructing generalized contours for areas where broad stretches of summit planes remain has been outlined and used by Maze (1944). He writes: "The 'high-points' plotted in each of the 1,000-yard squares, and used above for other methods of analysis, may be regarded as a set of spot levels occurring in the centre of each square. Such a series offers a suitable mesh of heights from which contours, with 200 feet vertical interval, can be drawn by the usual methods of interpolation." Such reconstructed contours dispense with the confusing detail of minor valley dissection.

Fig. 6 is a reconstruction of the high-point surface for the central Mount Lofty Ranges, using the method outlined by Maze. The contour interval is 100 feet. The shallow interval has effectively indicated the major fault escarpments, although it tends to mask the old erosion surface a little. The effects of minor stream erosion have been practically eliminated. The valleys of the major rivers are for the most part traceable except in those sections where gorge characters are strongly developed. For example, the course of the River Onkaparinga is not obvious where it has cut through the Ochre Cove escarpment, nor is the course of the River Torrens through the Eden escarpment.

The plan establishes the principal fault escarpments so clearly that detailed description is unnecessary. The major block faults can be traced clearly, and the reader is referred to fig. 2 for a key to the nomenclature adopted.

It is to be noted that the block-fault pattern produced is essentially similar to those outlined by Benson and Fenner. However, several minor faults postulated by these authors appear to the present writer to be based upon insufficient evidence,

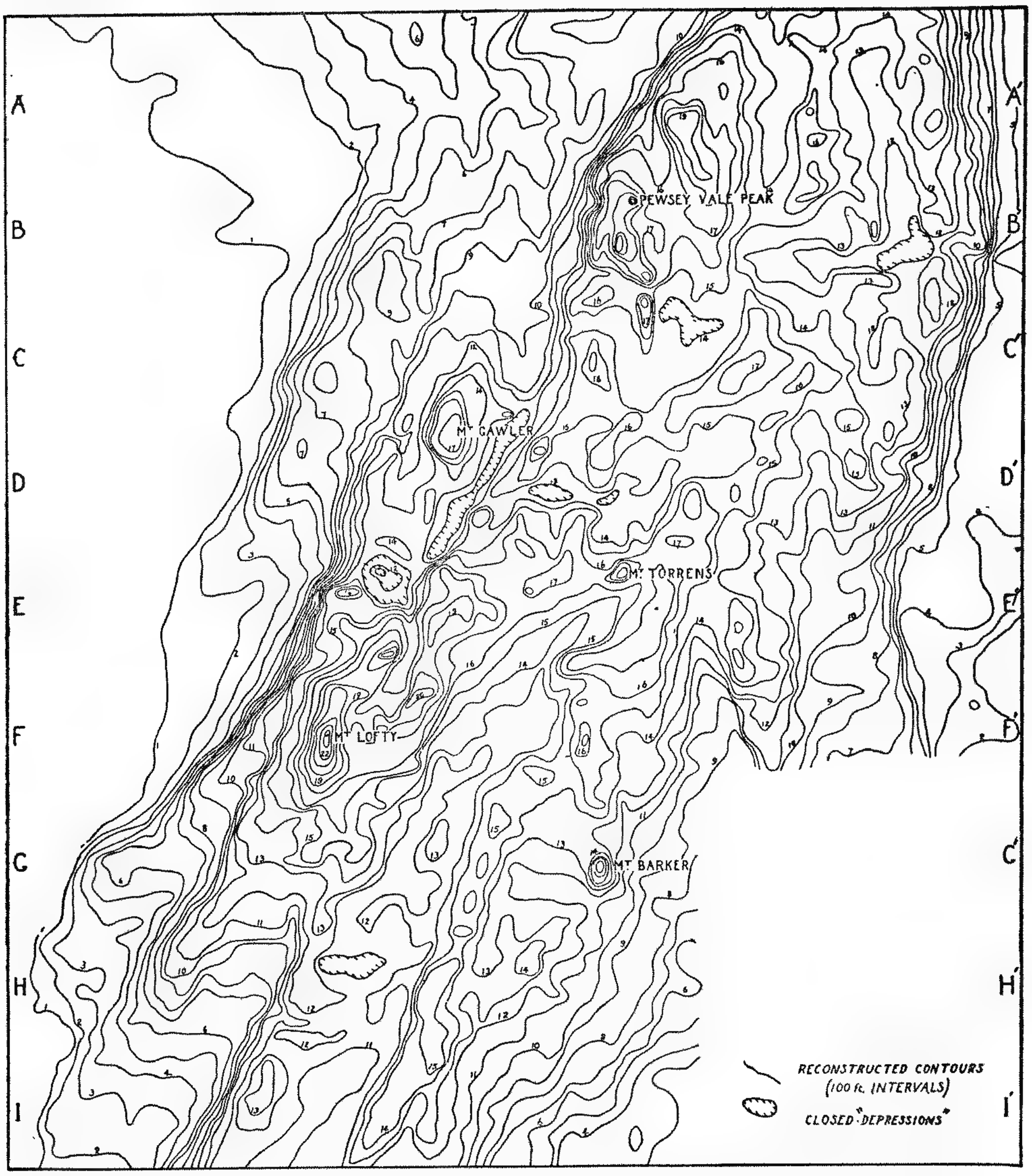

Fig. 6 Reconstructed or generalized contours for the Central Mount Lofty Ranges.

and the locations of several of the more prominent faults have also been modified. Statistical analysis suggests that the major faults are fewer in number than Fenner indicates—intensive field work in the western Mount Lofty Ranges confirms this. In the maps and diagrams which accompany this paper no attempt is made to indicate the location of a complex pattern of a series of ancient (Palaeozoic)

faults, the majority of which were inactive throughout the Kosciusko period of deformation. The relationship of these ancient faults to those of the Kosciusko epoch will be discussed in an associated paper to be published shortly which deals with the geology of portion of the western Mount Lofty escarpment region.

That the principal block-fault pattern conforms closely to the plan produced is strikingly apparent when the area is viewed from the air. The location of thick remnant Tertiary overmass sediments is confined markedly to many of the tectonic valleys.

A block model constructed directly from the generalized contour plan has been prepared and presented to the Department of Geology, University of Adelaide.

In the vicinity of Mount Lofty, however, the relationships of the various faults are still in doubt. Detailed geological reconnaissance mapping has revealed a number of ancient faults striking north-north-east in this vicinity. Between the main western escarpment fault (Eden) and Mount Lofty only one of these ancient faults (Ochre Cove fault) appears to have reopened during the Tertiary (Kosciusko) period of block faulting. The reconstructed contours indicate another escarpment immediately in front of Mount Lofty. It may be a fault escarpment or an ancient erosional feature.

To the east of Mount Lofty, almost in the projected line of strike of the Willunga fault, there is another problematical escarpment feature with (?) "downthrow" to the east. In the absence of sufficient field study, it is impossible to come to any satisfactory conclusion about it at present.

The fault fracture pattern is a simple one. The faults are arc-shaped, with convexity directed generally to the west. They are sensibly parallel. In the south as each block arches towards the coast, there is a notable increase in block width. Fault blocks to the south of Mount Lofty pitch to the south, and each one is tilted slightly to the east. In this manner a series of shallow "tectonic valleys" has been produced, trending a little east of north. The Para block shows similar relations in its southern extension, but in the north its direction of pitch is northerly. East tilting, if present, is not recognisable. The Gawler block pitches north beyond Mount Gawler. The main fault block, including Mount Lofty and Mount Kitchener, is tilted to the east.

The fracture pattern, the small hade of the block faults and the tilting of the separate blocks are typical of tension stress.

Several eminences stand in marked relief relative to the general erosion surface. In practically all cases these are monadnocks inherited from the early Tertiary erosion cycle. The most prominent are Mounts Lofty, Gawler, Torrens, Barker and Crawford and Pewsey Vale Peak.

On the lower slopes of Mount Gawler and around its base remnants of the early Tertiary lacustrine sediments, which once covered it, are still preserved. This and the other old monadnocks were buried by an accumulation of lake sands and clays before the transgression of the Miocene Sea and before block faulting occurred.

It is to be noticed that the Burnside splinter-block, which undoubtedly exists, is not evident on the plan. It has been obscured by outwash accumulations. This fault "splinter" and the south continuation of the Para block will be dealt with more fully in a later publication now in preparation.

Profile Projections in the Plane of the Meridian

An attempt has been made to illustrate the longitudinal warping and tilting of various of the fault blocks constituting the central Mount Lofty Ranges (fig. 7).

The Strip Profile method outlined above does not show this clearly. A modified method has been devised by the author which is calculated to satisfy special local conditions.

The maximum high-point value is selected from each grid strip trending approximately transverse (*i.e.*, east-west) to the elongation of the fault blocks.

It has been found that these high values are located towards the front (western aspect) on the blocks, as most of them are tilted down to the east. Care has been taken not to select values near the backs of the blocks, as such localities are frequently areas of accumulation and not erosion surfaces.

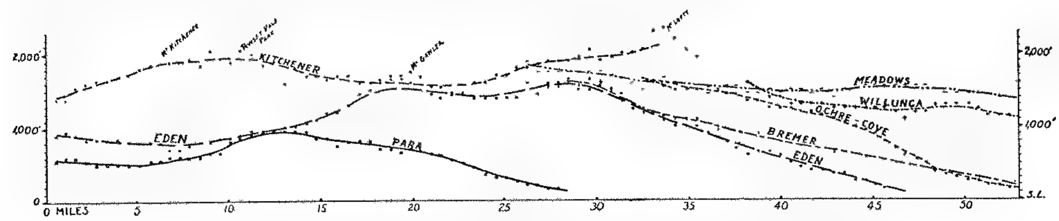

Fig. 7 Profile projections in the plane of the meridian.

Projecting these high-point values upon a north-south plane, a composite profile of the blocks as they appear from the west has been drawn up. Although all observations of high-point values have been recorded, the final curves were drawn to eliminate monadnocks and smooth out pronounced topographical irregularities. The effect, though less accurate, is more illustrative. The warping and tilting of the various blocks is shown plainly. The (?) downwarping between Mount Lofty and Mount Kitchener may be actual or may be the effect of river erosion.

Summary of Part I

Several methods of land-form analysis have been applied to the central Mount Lofty Ranges, and the state of preservation of the exhumed early Tertiary erosion surface has been demonstrated. The nature and extent of the (?) Kosciusko Period block faulting within the area has been outlined, and the tilting and warping movements of the separate blocks have been illustrated graphically.

Maximum elevation has occurred in a more or less central zone, which includes Mounts Lofty and Kitchener and which trends approximately north-north-east and south-south-west. This trend is set slightly obliquely to the boundaries of the horst range, which are approximately meridional. With the exception of blocks to the west of the Eden fault the crest zone is the locus of a change in direction of block tilt down. To the south and east the fault blocks are hinged down to the south. To the north and west they are hinged down to the north. The Para block and those beneath the Adelaide Plains have their crest lines located successively further north. The majority of the separate blocks are also tilted down to the east.

The block fault pattern is simple; it is considered that the form of block subsidences, the vertical hade and the arcuate plan of the faults are indicative of tensional stress. Longitudinal warping of the separate blocks in combination with the east-tilt factor has produced a series of tectonic valleys which exhibit an increase in the degree of development away from the locality of Mount Lofty. For the purpose of Part II of this paper, it is emphasised here that at some period these tectonic valleys must have exerted a control on drainage development.

Remnants of the early-mid Tertiary lignitiferous lacustrine "overmass" sediments are preserved in portions of the tectonic valleys, and to a lesser extent on the backs of blocks. The locations of some of them are indicated in fig. 2.

PART II. HYDROLOGY

A study of the erosional morphology of the Mount Lofty Ranges would be incomplete without reference to its drainage development. In this section of the paper the author has two distinct aims. In the first place an attempt has been made to apply recent techniques of statistical analysis of stream development to portion of the Mount Lofty Horst. Secondly, a new theory is advanced to explain the anomalous courses of certain major streams of the area, in particular the Rivers Torrens and Onkaparinga, which have been the subject of much discussion in the past. All authors, however, appear to agree with Fenner (1931) that "The controlling factor has been the tectonic fault and tilt movements, with capture, differential rock resistance, and possibly inheritance of earlier routes as secondary factors."

Benson (1909) considered that the winding course of the River Torrens showed independence of geological structure, and except in minor detail was not influenced by the variation of the hardness of the different strata through which it passed.

Howchin (1933, p. 30) writes: "With respect to the geological age of the river (*i.e.*, the Torrens—R. C. S.), the evidences seem to suggest that it was called into existence under the deformation that was incidental to the elevations of the Mount Lofty Ranges. In that movement the country received a tilt to the westward—a pitch down in the direction of the trough fault—which became the controlling factor in determining the lines of drainage on the southern side of the uplift, having a westerly direction."

Hossfeld (1935, p. 20), when referring to a part of the north Mount Lofty Ranges, noticed the complicated features resultant upon partial dissection of much of the former peneplain following differential elevation and tilting. He writes:

"1. All of the longer streams run meridionally for some distance from their sources, their courses being concordant with the strike of the rocks of the area. At some distance downstream, however, everyone of them changes its direction, disregarding the structure of the country entirely, crossing impartially, ridges and valleys, igneous and sedimentary, hard and soft rocks.

"2. In the meridional sections of their courses, the valleys are broad, gently graded, and approximately straight, and possess numerous highly mature tributaries. In the easterly or westerly sections, however, these streams flow through steep narrow gorges, over waterfalls and rapids, and pursue meandering courses irrespective of the structure or topography of the country. Furthermore, in general they have few long tributaries in this section; of these, most are mature in their upper reaches, and some for the greater part of their courses. The shorter streams pursue an easterly and westerly course along the whole of their length, and are in the juvenile stages of development."

Hossfeld (1935) considers the drainage system to have developed as follows: "The mature meridional sections of the streams are antecedent and represent the dismembered drainage of the former peneplain, probably dating from the Miocene period. Subsequent uplift, and east and west tilting, produced easterly and westerly meanders, grafted and the dismembered antecedent streams.

"The gradual elevation of the area resulted in the entrenchment of the meanders, and the rapid removal of Tertiary deposits, residual soils, and alluvium revealing the superimposed character of the east and west drainage. Rejuvenation of the upper sections and dissection of the remnants of the peneplain surface is going on rapidly."

Fenner (1931, p. 275) and Benson (1911, p. 111) each considered the possibility of river capture. With reference to the River Onkaparinga, Fenner writes:

"It was difficult to decide with any degree of certainty whether the gorge above Noarlunga was due to capture by headward erosion or to an antecedent position, though the latter theory is favoured in this book."

Benson records that "Rivers were captured, as the heads of the Onkaparinga by the Torrens, or revived with the formation of valley in valley structure, as in Foreston Creek near Gumeracha." In a footnote Benson adds that with reference to the capture of the Onkaparinga headwaters by the Torrens, Howchin had arrived at the same conclusion independently.

To overcome difficulties provided by certain physiographic structures, Fenner (1930, p. 17) introduced a theory suggested by Professor Douglas W. Johnson, of Columbia University, N.Y. The theory assumed "two dominant stages of block faulting with two periods of peneplanation, the latter planation being partly carried out in the softer Tertiary overmass." In pursuing the theory Fenner states "that the mature landscapes of the upper Torrens, upper Onkaparinga and other streams heading towards the Mount Pleasant area are difficult of explanation, unless we assume a long period of subaerial planation following the first uplift, some exhumation of the Pre-Miocene surface and some later tectonic influences, followed by the present cycle of erosion. The two or three western blocks that are truncated by the Torrens Gorge must have risen later and their topography, antecedent superimposed (Torrens, Para, etc.) and consequent with headward erosion (Morialta, Waterfall Gully, etc.), is in a youthful stage."

The present author has carefully considered this previous research on the evolution of the western Mount Lofty streams. Although in agreement with much of the factual evidence presented, it was felt that none of the theories advanced had explained satisfactorily certain unusual features of the rivers in question. An attempt has been made to rectify this in the second part of this portion of the paper.

Quantitative Hydrophysical Factors

Recently, Mr. A. E. Horton (1945) has shown how the problem of erosional morphology may be approached quantitatively. In applying methods to many areas in the United States he has referred particularly to the effects of surface run-off.

His methods, which are in part modifications of previous ones, provide the best means yet evolved of assessing drainage-basin development by surface water erosion. Certain of them will be used in this paper. It is hoped that the data which is thus produced will provide a basis for statistical comparisons with other Australian stream systems in the future.[3]

Several of the analytical methods will be referred to briefly and the data from their application to the Rivers Torrens and Onkaparinga produced in table form and discussed.

Stream Orders

In Europe attempts have been made to classify streams on the basis of branching or bifurcation. Horton has produced a modified method, in which the trunk stream is given the highest order and the unbranched fingertip tributaries are designated by the unit ordinal. In Horton's system (p. 281) "unbranched fingertip tributaries are designated as of Order 1, tributaries or streams of the

(3) The preparation of the base maps (from which quantitative data is directly measured) involves a personal element. This will be of little consequence where standards for the degree of detail adopted in map preparation are the same. However, if these standards vary from country to country, precautions will be necessary when it is desired to compare relevant statistics, particularly for minor streams.

second order receive branches or tributaries of the first order but these only; a third order stream must receive one or more tributaries of the second order but may also receive first order tributaries. A fourth order stream receives branches of the third order and usually also of the lower orders, and so on. Using this system, the order of the main stream is the highest."

Rules have been produced in order to determine which is the parent and which the tributary stream, upstream from the last bifurcation. Quoting Horton (p. 282) they are:

"(1) Starting below the junction, extend the parent stream upstream from the bifurcation in the same direction. The stream joining the parent stream at the greatest angle is of the lower order. Exceptions may occur where geologic controls have affected stream courses.

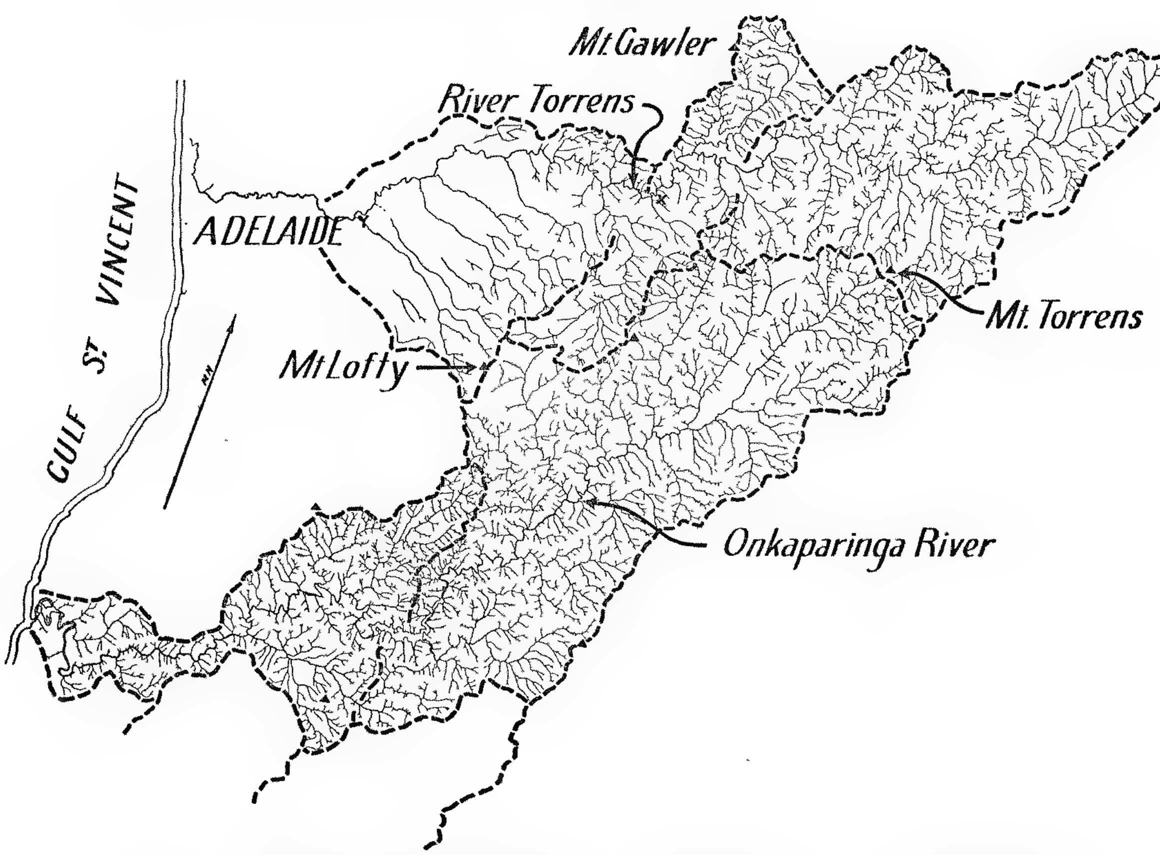

Fig 8 The Drainage Basins of the Rivers Torrens and Onkaparinga. The local divides of drainage nets and the subdivision of the trunk streams for polar analyses are indicated. The form of the drainage nets has been controlled by block faulting.

"(2) If both streams are at about the same angle to the parent stream at the junction, the shorter is usually taken as of the lower order."

For drainage nets of basins of comparable size, the determination of stream orders affords a simple quantitative basis for comparison of the degree of development in each case. Horton further notes (p. 283) that "Its usefulness as a basis for such comparison is limited by the fact that, other things being equal, the order of a drainage basin or its stream system generally increases with size of the drainage area."

DRAINAGE DENSITY (Horton 1945, p. 283-4).

The term "drainage density" is intended to characterise the degree of drainage development within a basin. It is the average length of streams within the basin per unit of area (Horton 1932). In equation form it is expressed by:

$$\text{Drainage Density, } D_d = \frac{\Sigma L}{A}$$

where Σ L is the total length of streams and A is the area, both in units of the same system. For example, a well-drained basin may have $D_d = 2{\cdot}78$, and the poorly drained one 0·72, or approximately one-fourth as great.

In this present contribution the analytical data has been obtained directly from Australian military maps. On these maps perennial streams are usually shown by solid blue lines, intermittent streams by broken blue lines. Both are included in the measurements.

STREAM FREQUENCY

Stream frequency is the number of streams, F_s, per unit area, or $F_s = \frac{N}{A}$ where N = total number of streams in a drainage basin of A aerial units.

Horton notes (p. 285) that the "Values of drainage density and stream frequency for small and large drainage basins are not directly comparable because they usually vary with the size of the drainage area. A larger basin may contain as many small fingertip tributaries per unit of area as a small drainage basin, and in addition it usually contains a larger stream or streams. This effect may be marked by the increase of drainage density and stream frequency on the steeper slopes generally appurtenant to smaller drainage basins."

BIFURCATION RATIO

The bifurcation ratio is the ratio of the average number of branchings or bifurcations of streams of a given order to that of streams of the next lower order. It is usually constant for all orders of streams in a given basin.

STREAM LENGTH RATIO

The stream length ratio is the ratio of the average length of streams of a given order to that of streams of the next lower order.

RATIO ρ

This ratio, which is that of the Stream Length Ratio to the Bifurcation Ratio, has been shown (Horton, p. 292) to be an important factor in relation to both drainage composition and the physiographic development of drainage basins. It is determined by "those factors—hydrologic, physiographic, cultural, and geologic —which determine the ultimate degree of drainage development in a given drainage basin."

LAWS OF DRAINAGE COMPOSITION (Horton 1945)

"(1) *The Law of Stream Numbers:* The numbers of streams of different orders in a given drainage basin tend closely to approximate an inverse geometric series in which the first term is unity and the ratio is the bifurcation ratio.

"(2) *The Law of Stream Lengths:* The average lengths of streams of each of the different orders in a drainage basin tend closely to approximate a direct geometric series in which the first term is the average length of streams of the first order."

These laws, which are the direct outcome of a mathematical study of stream development, are supplementary to Playfair's Law. This law of Playfair (see Tarr and Martin, 1914, p. 177) is stated as follows:

"Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size and all of them together forming a system of valleys, communicating with one another, and having such a nice adjustment of their declivities that none of them join the principal valley either on too high or too low a level."

COMMENTS ON VALUES OF HYDROPHYSICAL FACTORS OF THE TORRENS AND ONKAPARINGA DRAINAGE BASINS.(4) (See Table I).

The measured values of several more important physiographic factors for the two stream systems have been produced in table form together with certain other characteristics determined by simple calculation. The equations used in these calculations are indicated in Table I.

The measurements have been made directly from the latest military maps. The complete drainage basins of the rivers in question are considered. Both permanent and perennial streams are included. The drainage basins subdivide naturally into genetically related drainage nets, which themselves are determined by the major block faulting discussed in Part I. The divides between the separate drainage nets are indicated in fig. 8.

Stream Numbers—The law of stream numbers is obeyed closely by both streams.

Stream Lengths—The law of stream lengths is obeyed generally by streams of lower order. For higher order streams, however, major derivations from the mean are apparent. This immediately suggests that some geological control has interrupted normal stream development. The nature of this control is discussed later in this paper. Both drainage basins are strongly elongate. Therefore, in order that each may be drained satisfactorily, the main streams have lengths commensurate with those of the two basins. That is, the main streams in these cases are much longer than ordinarily would obtain for drainage basins of the same respective order, of normal form.

Drainage Density—The upper and middle drainage nets of the River Torrens represent good drainage conditions. The drainage density of the lower portion (down to Para Block fault) is relatively poor. This change is the result of the nature of the sediments and topography over which much of the lower net is distributed. Porous soils and the relatively low grades of those portions of the streams traversing the "plains" area combine to reduce the drainage density. That portion of the River Torrens between the Para fault and the sea is extremely poorly drained. Difficulties encountered in defining the limits of this lower drainage net prevented its accurate assessment.

The drainage densities of each drainage net of the River Onkaparinga are high, that of the central portion being extremely so. The Onkaparinga Basin is better drained than the Torrens Basin.

Stream Frequencies—The stream frequencies of both basins and their separate drainage nets exhibit relations similar to those of Drainage Densities. The extreme variants, however, are more pronounced.

Bifurcation Ratios—Horton has pointed out that, in general, a ratio of about 2 indicates flat or rolling drainage basins, whereas a value of 4 indicates mountainous or highly dissected drainage basins. On this assumption then, with the exception of the Upper Onkaparinga net, the headwaters of each drainage net

(4) Small variations in the degree of minor stream detail reproduced on the military maps reduces the accuracy of some of the physiographic factors. In dealing with small areas, it appears advisable that aerial photos should be used to determine minor stream detail. In this paper, for broad analysis and generalizations, the values quoted are of value.

TABLE I HYDROPHYSICAL FACTORS

		RIVER TORRENS†				RIVER ONKAPARINGA			
		DRAINAGE NETS			DRAINAGE BASIN	DRAINAGE NETS			DRAINAGE BASIN
		UPPER	MIDDLE	LOWER		UPPER	MIDDLE	LOWER	
Arear (in Square Miles): A		85·8	39·4	70·3	195·5	152·2	45·2	15·6	213·3
Stream Numbers: N - -	1st Order	453	213	124	790	990	435	108	1,533
	2nd ,,	142	71	48	261	263	103	33	399
	3rd ,,	32	12	11	55	88	32	4	124
	4th ,,	11	2	1	14	24	3	1	28
	5th ,,	3	1	—	4	10	2	—	12
	6th ,,	1	Trunk	Trunk	1*	3	—	—	3
	7th ,,	—	—	—	—	1	Trunk	Trunk	1*
	Total - -	642	299	184	1,125	1,379	575	146	2,100
Stream Lengths: L - - (in Miles)	1st Order	103	46	45	194	200	69	21	290
	2nd ,,	80	38	43	161	150	46	17	213
	3rd ,,	52	26	32	110	97	34	7	138
	4th ,,	35	12	10	57	51	11	4	66
	5th ,,	12	9	—	21	50	12	—	62
	6th ,,	24	(8)	(18)	50	17	—	—	17
	7th ,,	—	—	—	—	32	(16)	(12)	60
	Total - -	306	139	148	593	597	188	61	846
Drainage Density— $D_d = \frac{\Sigma L}{A}$		3·6	3·5	2·0	3·0	3·9	4·0	3·9	4·1
Stream Frequency - - $F_s = N/A$		7·5	7·6	2·6	5·8	9·0	12·7	9·4	9·9
Bifurcation Ratio— r_b	3rd-2nd Order	3·2	3·9	3·4	3·4	2·8	3·7	4·0	3·2
	4th-3rd ,,	2·8	2·7	1·5	2·6	2·7	2·8	2·0	2·2
	5th-4th ,,	0·9	1·5	—	0·9	1·9	2·0	—	1·2
	6th-5th ,,	6·1	—	—	6·7	1·5	—	—	2·3
	7th-6th ,,	—	—	—	—	4·6	—	—	8·8
Stream Length Ratio— r_l	2nd-1st Order	2·6	2·5	2·5	2·5	2·8	2·9	3·6	2·8
	3rd-2nd ,,	2·1	3·9	3·2	3·0	2·0	2·3	3·2	2·1
	4th-3rd ,,	2·0	5·4	3·4	1·6	1·9	3·1	3·0	2·2
	5th-3rd ,,	1·2	0·8	—	2·1	2·4	1·7	—	2·1
	6th-5th ,,	6·0	—	—	7·0	1·1	—	—	1·1
	7th-6th ,,	—	—	—	—	5·0	—	—	10·0
Length of Main Stream (in Miles)		24	8	18	50†	32	16	12	60
Total No. of Streams ΣN		642	299	184	1,125	1,379	575	146	2,100
Order of Main Stream -		6	6	4‡	6	7	6‡	5‡	7

† Portion of Drainage Basin beyond the Para Block fault has not been taken into account.
* Trunk (Main) Stream is common to each Drainage Net, and therefore is not totalled in Stream Numbers.
‡ Order of Trunk Stream considered only in respect to relevant Drainage Net.

constituting the Torrens and Onkaparinga drainage basins should be in well dissected terrain. This is the case. The low values obtaining for higher order stream ratios probably indicate lower stream grades in the central portions of the drainage nets. These facts apparently demonstrate the existence of strong geological controls. The Mount Lofty horst is a faulted plateau region in an advanced stage of dissection by "youthful" streams. For the most part higher order streams are confined to the "backs" of fault blocks. The lower order streams are more frequent along fault scarps and adjacent to the gorges of high order streams where the latter have cut through the western upturned edges of fault blocks.

Stream Length Ratios—In general the values of this ratio are reasonably constant within each drainage net or basin. However, major deviations are evident in the case of the higher order streams. These streams are abnormally long.

Observations—From the above data it is clear that the two river systems have had very similar evolutionary histories. Both drainage basins are readily sub-dividable into several nearly closed drainage nets which are strung out along the course of the trunk stream. In the case of each drainage basin, a strong geological control has been in action producing abnormally long trunk streams. The similarities in historical development will be amplified further when their respective stream patterns and geological history are considered.

Analysis of Trunk Streams using Polar Diagrams, with special reference to the Evolution of the River Torrens — a Theory of River Capture.

This occasion appears to be the first in Australia in which extensive use is made of polar diagrams in an attempted solution of the anomalous courses of streams.

The method is simple. The compass directions are divided into 36 10° sectors, and each 10° sector represented by a radius on a polar circle. The relative distances traversed in each of these sector directions by any particular river is then plotted along the respective radii. In the case of a stream flowing over gently graded alluvials which possess no natural barriers, its diagram should approximate an ellipse with major axis in the direction of highest gradient. However, if geological controls are active within a particular drainage net, the resultant diagram may exhibit anomalous features.

In the Mount Lofty Ranges strong geological controls are frequently in evidence. The present study applying to the western aspect of the ranges has produced evidence which warrants the formulation of a new theory based on river capture.

When considering the possibilities of such river capture the following two factors are important:

(1) The greater rainfall and hence more rapid erosion along the western scarp; a relative "rainshadow" exists on the east.

(2) Steeper gradients associated with the western escarpments.

Under these conditions it may be assumed that in the history of the development of the Mount Lofty Ranges the main watershed divide between the eastern and western escarpment streams has migrated to the east. On this assumption, then, the possibility of river capture operating from the west is a distinct one.

In order to highlight anomalous directional tendencies, which may be interpreted fairly as indicating previous headwater piracy, the River Torrens has been

divided into "natural" segments, based on the block fault plan produced earlier in this paper. The major directional changes have also been taken into consideration. A polar diagram has been prepared for each of the segments so decided upon. Their location is indicated in fig. 8.

A study of these polar diagrams (pl. xix B) indicates that the River Torrens in its approaches to each block fault (fig. B, D and F) flows in a direction sensibly parallel to a line drawn at right angles (the "normal," N.) to the respective block fault. Such sections of the stream coincide in the direction of flow with the normal "consequent" escarpment streams occurring along each block-front escarpment. In the remaining segments of the stream the major direction of flow is definitely at variance with these escarpment segments, *i.e.,* along the tectonic valleys at the back of the fault blocks.

In view of these facts it is probable that the theory of an inherited (*i.e.,* antecedent) course preserved from the original surface of the Tertiary overmass beds does not hold. Hossfeld's descriptive summary of the outstanding features of streams of the north Mount Lofty Ranges (see p. 289 of this work), however, holds admirably for a theory of river capture which will now be developed.

With the formation of the block mountain range, a series of N.N.E.-S.S.W. tectonic valleys were formed, a result of the accompanying east tilting of the separate blocks (see Part I). The pivotal movement relative to the major upwarp marked by Mounts Lofty, Torrens and Kitchener and Pewsey Vale Peak was with downthrow to the south in the south, and to the north in the north.

These tectonic valleys confined drainage from the upland area. Hence, although the escarpments possess strong westerly aspects, many of the earlier major streams ran N.N.E.-S.S.W. or S.S.W.-N.N.E. They were therefore "consequent" streams, owing their development to upwarping and to block faulting. A second related series of "consequent" streams developed contemporaneously from the escarpments. These two types will be referred to hereafter as the "escarpment consequents" and the "tilt consequents" respectively.

In order to understand the mechanics of the river capture theory several segments of the River Torrens are now considered in more detail.

Referring in the first place to that section of the Torrens between the big bend (marked X on fig. 8) and the Eden block fault, the average directional trend (pl. xix, fig. D) is a little to the north of west. This corresponds to the direction normal to the strike of the local block fault, so the consequent nature of the stream is pronounced here. In contradistinction the segment from X to the Kitchener Block fault exhibits a pronounced tendency to meridional flow (see pl. xix, fig. C).

The Millbrook (or Chain of Ponds) Creek, which enters the River Torrens on this segment, also follows the S.S.W. direction; further, the divide beyond the former's headquarters is so low that it is easy to conceive of the Millbrook Creek as originally flowing N.N.E. as portion of the South Para River headwaters (Malcolm Creek). Its course was later captured (with part reversal of flow) by the advancing headwaters of the juvenile Torrens (an escarpment consequent stream near Hope Valley). Such northward flow of the South Para River headwaters would not be abnormal, as the nearby Little South Para shows similar tendencies. Again, it is possible that even Deep Creek (or Upper Sixth Creek) may represent the original south extension of the Malcolm Creek. For the major portion of its course it bears directly towards Millbrook Reservoir (and parallel to the "front of range" fault). The sharp right angle bend at the deviation from this direction is quite typical of the postulated river capture system of the western Mount Lofty Range.

The River Torrens then, as a result of higher stream gradient and early erosion in soft overmass, succeeded in capturing the south headwaters of the South Para River. These latter headwaters once flowed along a depression line at the "back" of an east-tilted faulted block.

In the vicinity of Cudlee Creek, escarpment formation also was responsible for rapid headwater erosion by small "escarpment consequent" streams. One such stream cut back towards Birdwood and finally captured the headwaters of the ancient Onkaparinga. Whether the capture was effected before the juvenile Torrens had captured the headwaters of Malcolm Creek is uncertain. However, it is more probable that this happened subsequently; the steepening of the grade of creeks draining from Kitchener Scarp caused by a shortening of their courses by the river capture would increase their erosive power locally. Much of the erosion up to this time had taken place in the soft Tertiary sedimentary overmass, and hence probably many streams had eroded back into the escarpment. Only that stream which succeeded in capturing a big flow of water would be able to maintain its gorge when eventually the harder overmass rocks were exposed. The anomalous kink in the Torrens Gorge in its course across the escarpment segment of the Kitchener Block may be due to a rock structure or subsidiary river capture.

Concerning the headwaters of the modern streams, it is noticeable that the River Onkaparinga bears certain significant relations to that of the River Torrens above Birdwood. Benson (1911) and Howchin (1918) have recognised the possibility that the modern Torrens headwaters were once those of the original Onkaparinga. It is suggested that the probable "link" is the Angas Creek, which possesses a deep and wide valley characteristic of a stronger stream and therefore suggestive of a more complex history. Its valley slopes rise to the east 250 feet and to the west 500 feet (Mount Torrens), and its valley bottom is quite broad. The headwaters of the Angas Creek are separated by a low divide from those of the Onkaparinga.

A possible alternate course for the old Onkaparinga, in the vicinity of Mount Torrens, is to the west of this monadnock.

A notable feature of the modern Onkaparinga is its relatively direct S.S.W. course from Mount Torrens to the Mount Bold Reservoir. It is running parallel to the postulated north continuation of the Meadows fault. At Mount Bold the sharp bend to the west suggests (as Fenner 1931, p. 273, has noted) river capture by a swift flowing high-graded stream crossing the Willunga Scarp from the west. The divide which separates the River Onkaparinga from the Kuitpo Valley Creek is quite low. It is probable that the ancient Onkaparinga flowed along the Kuitpo Valley to join the River Finnis. This latter creek, too, shows an anomalous course; this has been noted by Mawson (personal communication). However, it is beyond the area discussed in this paper.

To recapitulate chronologically (see fig. 9), possibly as early as the close of the Miocene period, block faulting of the Kosciusko Epoch had commenced to form the Mount Lofty Horst. By Pliocene time shallow arms of the sea had advanced over low-lying portions of various pivotal blocks. One such incursion occurred about the site of Adelaide and Paradise. Into this depression ran a number of "escarpment consequents" streams draining from the low range appearing to the east (fig. 9 A). A more northerly escarpment stream was destined to become the River Torrens after a complex history of river capture.

As the differential uplifting and combined tilting of the various blocks became prominent, streams on the back of the block (tilt consequents) came to conform with tectonic valleys so produced.

By virtue of higher stream gradient over easily eroded Tertiary sediments the juvenile Torrens was able to erode back through the rising scarp, to capture

and so dismember the south headwaters of the South Para River (fig. 9, B). By continued headwater erosion through a second Kitchener scarp the Torrens finally captured the headwaters of the ancient Onkaparinga (fig. 9, C).

Contemporaneously the old Onkaparinga suffered further dismemberment south along its course. Originally it had flowed along the "back" of the Willunga Block along the tectonic valley via Meadows and Myponga, probably reaching the sea at Normanville. Its flow probably first became diverted through to the sea at Myponga, and then later towards Lake Alexandrina along the present course of the Finnis River (see fig. 1). Within the area with which this contribution is mainly concerned, its flow then became diverted once more to the west, near Mount Bold, because of the higher erosive power of a consequent stream draining from the Willunga Scarp toward Noarlunga. In this manner the original

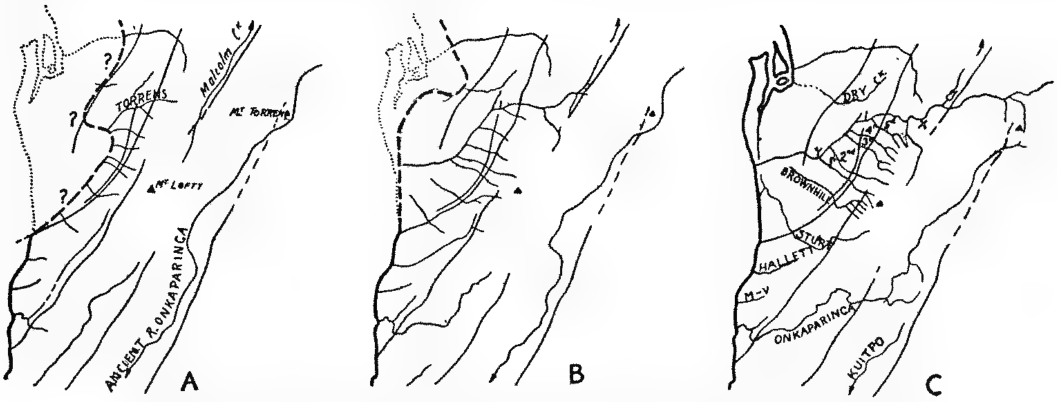

Fig. 9 Suggested stages for the evolution of the River Torrens and Onkaparinga, based on a theory of river capture.

Onkaparinga has been dissected into six segments, the three northernmost forming the nucleus of three major streams of the western Mount Lofty Horst. Additional capture probably occurred near Noarlunga across the Ochre Cove fault escarpment.

During the late Pliocene Period, with the recession of the sea from the vicinity of Adelaide, the various escarpment streams became engrafted to form a series of tributaries of the main Torrens River System (fig. 9, C). These tributaries were consecutively the Fifth, Fourth, Third, Second, First, Brownhill and Sturt Creeks.

Some Observations

No attempt has been made to criticise formally the "double peneplanation" theory of W. D. Johnson and C. Fenner. However, a few brief comments are made below.

Fenner (1930) has mentioned "peculiarities of certain critical areas, such as the Torrens Valley on the one hand, and the coastal strip that runs from O'Halloran Hill to Myponga on the other," which could be better explained by assuming two dominant stages of block faulting, with two periods of peneplanation, the later planation being partly carried out in the softer Tertiary "overmass." It seems that he is referring to signs of very recent movement along the Para fault, and along other faults in the western portions of the Mount Lofty Horst, and to the existence of mature landscapes of the upper Torrens, upper Onkaparinga, and the other streams heading towards the Mount Pleasant area.

Although the author agrees that these faults have been active recently, there seems no reason to infer that the activity followed a period of protracted still-

stand (and peneplanation). The "friable, dissected, horizontal, ferruginous, beds of (?) Pleistocene age that remain against the main Mount Lofty Scarp on the south side of Anstey's Hill road," which are considered to be further evidence of this uplift after still-stand, are Pre-Miocene Marine "overmass" sediments which in part may have been redistributed.

The mature landscapes of the Mount Pleasant area are said to be "difficult of explanation unless we assume a long period of sub-aerial planation following the first uplift, some exhumation of the Pre-Miocene surface, and some later tectonic influences, followed by the present cycle of erosion" (Fenner 1930).

In the Mount Pleasant locality streams possess low grades, and hence low erosive power, for at least two reasons. Firstly, they are on a tableland with a well-developed "fossil erosion surface" which has not long been exhumed from beneath the soft "overmass" sediments. The topography here then is "young, little dissected," but not "mature." Secondly, river erosion within the area has been inhibited by the tectonic valleys which strike more or less parallel to the range. Originally drainage to the sea was controlled by these longitudinal valleys, and hence the average stream gradient was much less steep than it would have been via much shorter courses disposed transversely to the range. Under these conditions stream erosive power was proportionately less powerful. However, when river piracy short-circuited the headwaters of tectonic valley streams, the "local base level" at the point of capture was rapidly lowered, giving in effect just such "rejuvenation" as the "double peneplanation" theory was calculated to account for.

It is to be noted that the high level occurrences of laterite formed on "undermass" and "overmass" sediments may favour a short period of relative still-stand during block faulting. Their formation apparently coincided with a humid pluvial period prior to the Pleistocene Period (Crocker 1945). Lateritic ironstones have been formed partly on Pre-Cambrian slates, quartzites and limestones and partly on older Tertiary sands. To associate their formation with the unqualified term peneplanation" is undesirable, as it implies a very lengthy period. Laterization was almost certainly post-Miocene and Pre-Glacial—relatively a short period.

On the original rising area of weak overmass sediments it is probable that vertical corrosion never exceeded horizontal grading, nor the general wearing down of the surface. In this manner the landscape on which laterization occurred was an "old from birth" base surface. It would correspond with Johnson and Fenner's second period of peneplanation.

Concerning the age of laterization it is hoped that investigations to be undertaken shortly on bore material from the Adelaide Plains will produce valuable evidence. The considerable thickness of reddish clays within the post-Upper Pliocene Alluvials (= Tate's mammaliferous drift) may be correlated in part with laterization. Floaters of lateritic ironstone, if found within the clays, may indicate dissection of the laterite beds elsewhere.

The author's theory of river capture is in contradiction to Howchin's reference (1918) to the Torrens and other streams as antecedent superimposed. The remarkable coincidence in the larger segments of these streams with block fault structure renders Howchin's theory untenable. The stream courses may be regarded as superimposed in that they have been carried through from overmass strata on to an old erosion surface, but the major relevant structures in both cases have been controlled by the block faulting movements.

Tributaries of the River Torrens

Polar analysis of the main escarpment tributaries of the lower Torrens drainage net has proved invaluable in demonstrating the genetic relationships of a series of streams. These tributaries are consecutively the Fifth, Fourth, Third,

Second, First, Brownhill and Sturt Creeks (fig 9 C). They owe their development largely to escarpment formation, but their polar diagrams have indicated other influences and the extent of their effect.

Polar diagrams have been prepared for each of these main creeks in the lower Torrens Basin, and these will be dealt with briefly.

Fifth Creek (pl. xixA)

The polar diagram at first may appear misleading, but the "consequent" nature of the stream is readily established when the normal to the local strike of the escarpment is superimposed on the diagram. That the creek has not followed the exact direction of natural slope for any significant distance must be fortuitous. The noted deflection to the south-west can be accounted for by a strong quartzite barrier faulted across the course of the stream. The more northerly deflection may be partly due to a tilt-down to the north of the Mount Gawler Block.

Fourth Creek (pl. xix A)

The Fourth Creek-Sinclair Gully pattern is that of a consequent stream, in part affected by the differing hardness of sedimentary strata. The strong south-east prolongation represents the deflection of the stream by the Rock Hill Thick Quartzite massif. The diagram for the south member indicates a lateral tributary.

Third Creek (pl. xix A)

A normal consequent stream traversing no very significant barriers.

Second Creek (pl. xix A)

This stream presents a typical consequent diagram, although there is a tendency to be diverted west-south-west by the massive Thick Quartzite outcrop at Slapes Gully.

First Creek (pl. xix A)

Both tributaries of this creek have been "analysed" and the diagram so obtained is simple. Its major prolongation almost coincides with the direction at right angles to the local strike of the block fault. Accordingly, the stream is normal "consequent."

Brownhill Creek and Tributaries (pl. xix A)

In attempting to "solve" this irregular creek, separate diagrams have been constructed, but are not reproduced herein. Their separate traces are thought to be typical of a series of tributaries constituting a basin. Diagram G represents the course of the creek across the plains. It provides an excellent example of a creek traversing a gently graded alluvial fan, the normal to the strike of the local fault scarp providing the dominant direction of flow. First to Fifth Creeks, in their courses across their respective alluvial fans, should analyse similarly, but only the portions of those creeks above the main block fault have been analysed on the accompanying diagrams. The analytical data for Brownhill Creek and its lateral tributaries down to the main scarp fault has been superimposed to give a single resultant curve (see composite diagram). The average trend indicated is between 30° and 40° in an anti-clockwise direction from that of the block fault "normal." This more southerly flow is due to the south dip of the Eden-Moana Block surface consequent upon "pivoted" faulting. The pivotal influence, namely a south pitch, is recognisable as far north as Mount Osmond.

In a similar manner a northerly tendency of flow may be accounted for in Fourth, Fifth and Sixth Creeks and in the upper Little Para, due to a reversal in direction of tilt to the north.

The River Sturt (pl. xix A)

Once more in an attempt to "solve" the complex pattern of this creek system, separate diagrams were prepared for natural sections of the river and for tributaries. These do not give a clear picture, but the composite diagram provides a solution. As with the case of Brownhill Creek the diagram indicates a stream affected by two controlling factors, namely, the block fault scarps and the south tilt of the block over which the stream flows. As the vector value of the degree of south tilt of the block is becoming relatively stronger in relation to intensity of western escarpment formation, so the analysis diagram presents a greater and more uniform spread. Hence a definite grading is observable from Second Creek through First and Brownhill Creeks to the River Sturt, as the second factor (south tilt) becomes important.

As Fenner (1931) has suggested, the right angle bend of the River Sturt, near Flagstaff Hill, suggests river capture from the west.

Notes on Examples of River Piracy observed within the Area

In attempting to reconstruct the evolutionary history of the Rivers Torrens and Onkaparinga, river capture has been held responsible for many of the anomalous bends noticeable in their courses. From the study made, there seems to be little doubt that further signs of such piracy should be found in the area. This is so.

Dr. Fenner (1931) has recorded a probable example as follows: "There is evidence in favour of the theory that the Sturt originally flowed down the tectonic valley formed by the Sturt and Belair Blocks (at the back of the Eden Block, R. C. S.), and flowed into Hallett's Creek (Happy Valley). The evidence consists of the characteristic elbow bend and gorge north of Flagstaff Hill, with a low gap and sands at the head of Happy Valley. Thus the Sturt is led through the scarp face to the west. . . . ." The drainage basin of the Sturt and Hallett Creeks are shown on fig. 10 B.

A parallel case of such piracy concerns the lower drainage nets of the River Torrens and the Dry Creek drainage basin. (fig. 10 A). However, on this occasion the position of the master stream is reversed. A small escarpment stream has captured a tributary of one of the principal drainage basins of the Mount Lofty Ranges.

Fig. 10

Professor Howchin (1918) describes a case of stream piracy which has occurred three miles north of Palmer: "A creek formerly flowed south, on the western side of a range of hills, and passed near Palmer; but the Milendella Creek from the opposite side of the range cut its way back by means of a waterfall through the range and tapped the stream on the other side."

Summary of Part II

Several techniques of statistical analysis of stream development as developed or modified by A. E. Horton have been described briefly and applied to the area. The data so obtained indicated that strong geological controls have operated. These controls are the tectonic valleys and steep fault escarpments described in Part I of this paper.

Polar diagrams have been used extensively in the analysis of the direction of flow of trunk streams. The River Torrens has been treated in this manner, and from the information forthcoming, it is evident that river piracy has played a much greater part in the history of many of the major streams of the western escarpments than hitherto has been realised. Also, a series of escarpments consequent streams have been submitted separately to polar analysis, and their diagrams have indicated the complicating effect of fault block tilting. The effects of individual rock structures have not warranted detailed attention.

Several weaknesses in the evidence for the theory of "double peneplanation" as advanced by W. D. Johnson and C. Fenner have been outlined.

Concerning the evolution of the modern drainage of the area, Fenner has summarized the important facts admirably as follows: "The controlling factor has been the tectonic fault and tilt movements, with capture, differential rock resistance, and possibly inheritance of earlier routes as secondary factors."

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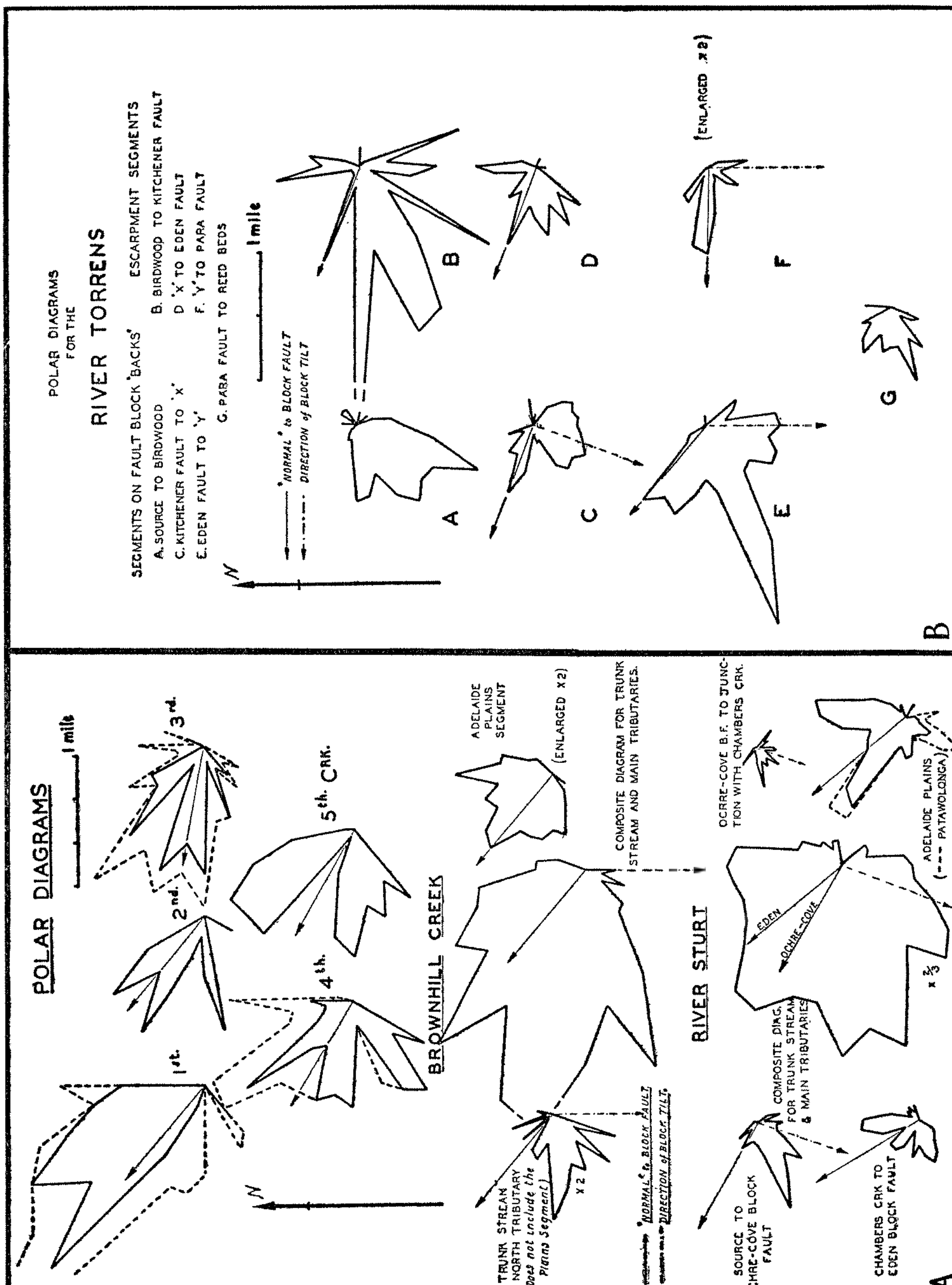
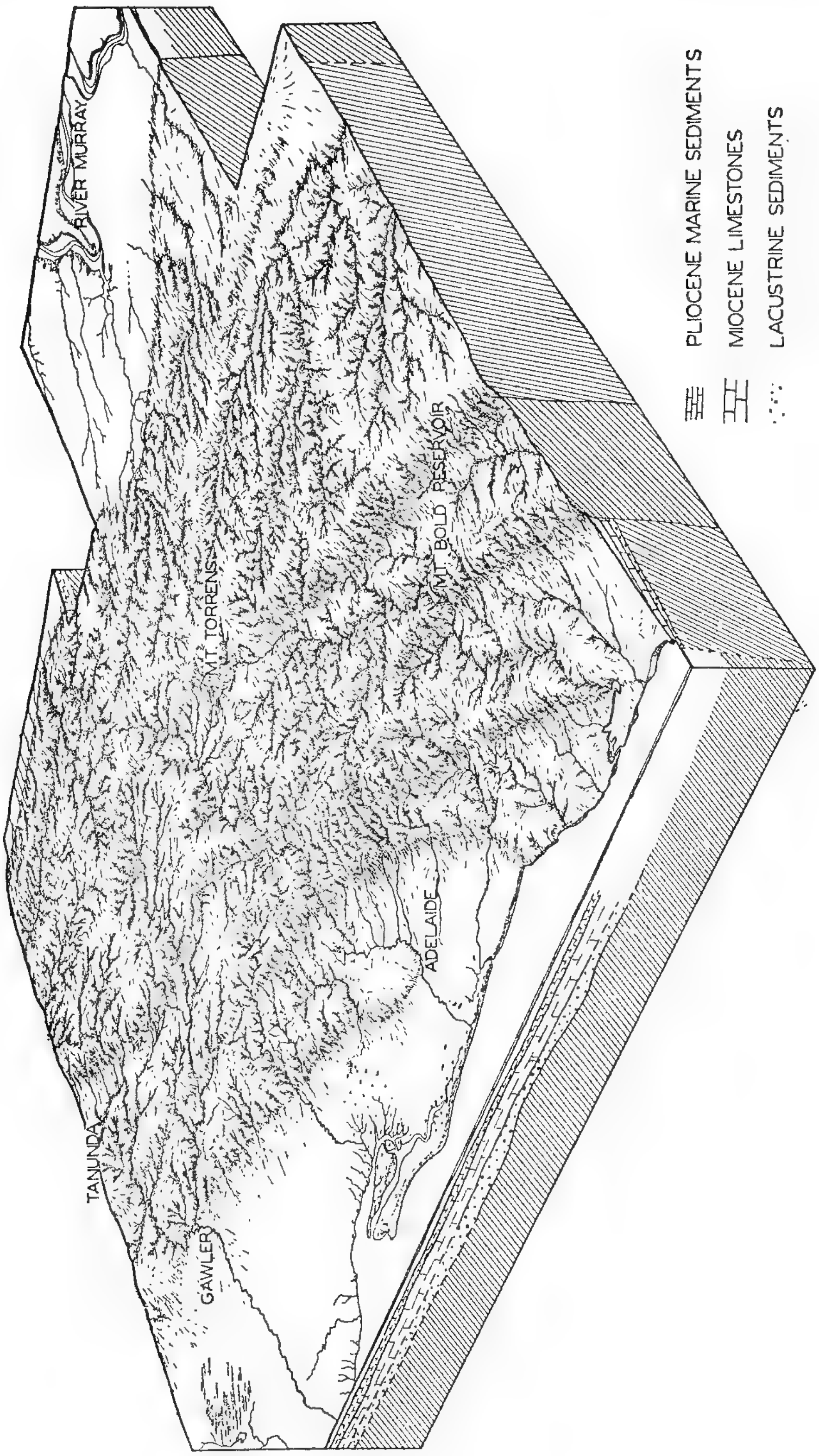

POLAR DIAGRAMS
FOR THE
RIVER TORRENS
SEGMENTS ON FAULT BLOCK 'BACKS'
A. SOURCE TO BIRDWOOD
C. KITCHENER FAULT TO 'X'
E. EDEN FAULT TO 'Y'
ESCARPMENT SEGMENTS
B. BIRDWOOD TO KITCHENER FAULT
D. 'X' TO EDEN FAULT
F. 'Y' TO PARA FAULT
G. PARA FAULT TO REED BEDS
1 mile
'NORMAL' to BLOCK FAULT
DIRECTION of BLOCK TILT
N
A
B
C
D
E
F
G
(ENLARGED x2)
B
POLAR DIAGRAMS
1 mile
1st.
2nd.
3rd.
4th.
5th. CRK.
N
BROWNHILL CREEK
ADELAIDE PLAINS SEGMENT
(ENLARGED X2)
COMPOSITE DIAGRAM FOR TRUNK STREAM AND MAIN TRIBUTARIES.
TRUNK STREAM + NORTH TRIBUTARY (Does not include the Plains Segment)
X 2
'NORMAL' to BLOCK FAULT
DIRECTION of BLOCK TILT
RIVER STURT
OCRRE-COVE B.F. TO JUNCTION WITH CHAMBERS CRK.
ADELAIDE PLAINS (--- PATAWOLONGA)
EDEN
OCHRE-COVE
x 2/3
COMPOSITE DIAG. FOR TRUNK STREAM & MAIN TRIBUTARIES
SOURCE TO OCHRE-COVE BLOCK FAULT
CHAMBERS CRK TO EDEN BLOCK FAULT
A


RIVER MURRAY
MT. TORRENS
MT. BOLD RESERVOIR
ADELAIDE
TANUNDA
GAWLER
PLIOCENE MARINE SEDIMENTS
MIOCENE LIMESTONES
LACUSTRINE SEDIMENTS

MORPHOLOGY AND ANATOMY OF THE WESTERN AUSTRALIAN SPECIES OF TRIODIA R. BR.

I. GENERAL MORPHOLOGY

By NANCY T. BURBIDGE, M.Sc., Waite Agricultural Research Institute

[Read 13 September 1945]

PLATES XXI TO XXV

In the course of a taxonomic study of the genus *Triodia* R. Br. interest was aroused concerning the general structure of the plants and their internal anatomy. Owing to war-time difficulties publication has been delayed. The present contribution is the first of a series dealing respectively with: I, General Morphology; II, Internal Anatomy of Leaves; III, Internal Anatomy of Root and Shoot; and IV, Seedling Anatomy and Development.

GENERAL HABIT

The plants under discussion are all xeromorphic tussock-forming perennial grasses, occurring in the arid summer-rainfall areas of tropical Western Australia. Information concerning the type of habitat has already been published (2, 3).

The coarse tussocks have projecting pungent-pointed leaves and the form may be pyramidal, flattened, ring-shaped or crescentic. In the first case the growing shoots are at or near the whole periphery. In the second, growth is made on the lower parts of the circumference or the tussock may be formed by the development of long stolons, each of which has a tuft of shoots at its apex. These tufts commonly become rooted and may ultimately attain complete independence. The result is a tangled mass of stolons and tufts (pl. xxii, fig. 1 and 2). Crescentic and ring tussocks are formed by the death of the central older portion. Owing to the rooting of the various culms, the tussocks become multiple plants or colonies. Stages in the development of a ring are seen in the series of photos in pl. xxi. Permission to publish these was kindly given by Mr. C. P. Mountford, who obtained them in Central Australia.

Where tussocks are adjacent they may merge to form a compound structure which attains a considerable size. Plants up to 2 metres high have been reported in *Triodia pungens* R. Br. and *T. longiceps* J. M. Black.

No type of tussock is confined to one species but the form of each has its particular characteristics, which are shortly described as follows:

T. pungens R. Br.: all tussock forms described above occur in this polymorphic species, which is widespread from Western Australia to Queensland and which is the only one of any real economic importance. The different types observed were described in the taxonomic paper.[1] The leaves are resinous.

T. Basedowii Pritzel: a rigid pyramidal tussock, becoming annular or crescentic.

T. lanigera Domin: a coarse species forming large irregular pyramidal tussocks. The leaves are glaucous, giving the plant a drab appearance.

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T. Wiseana C. A. Gardner: a compact almost globular tussock. The green leaves of the new growth are conspicuous against the straw-coloured and dry sheaths of the older leaves.

T. brizioides [1] N. T. Burbidge: similar in general form to the preceding but the leaves are glaucous (pl. xxii, fig. 3).

T. irritans R. Br.: young tussocks pyramidal. Older ones low, flat and straggling with a tendency to ring formation.

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Roots and Shoots

The culms in all species are formed by a number of long internodes followed by a number of short ones. Axillary shoots develop in the leaf axils of the latter. Of these axillaries the lower develop in the same way as the parent culm, while the upper commonly remain erect and form the tufts mentioned above. The apex of the parent culm or of any of the culms secondary to it gives rise to the panicle, which is always terminal. Thus the branching is centrifugal, and one is tempted to use the word cymose (pl. xxiii, A, B and C). It has been reported that in *Saccharum spontaneum* L., if growth is interrupted by grazing or by fire, then a series of long internodes on a culm may be followed by several short ones before long internodes are again developed (1). No such accidental interruption occurs in *Triodio*. *T. pungens,* while growing vigorously under glasshouse conditions, developed the alternate series of long and short internodes so characteristic of all species (text fig. A). On a long internode portion the nodes may be exposed and the laminae of the leaves reduced. On a short internode section the nodes are hidden by the sheaths unless there is displacement due to curvature.

There is a tendency for the long internode sections or stolons to be horizontal. They are rarely sufficiently robust to hold aloft the apical tuft of axillary shoots. As a result curvature of the short internode portion is necessary if the axillary, apogeotropic intravaginal shoots (1) are to stand erect. Curvature takes place with the bending of the unthickened basal region of the internode and of the pulvinal development of the subtending leaf sheath-base (pl. xxiv, fig. 3). There is no geotropic tendency in the orientation of the stolons, which become horizontal owing to a passive response to the weight of the apical tuft. In a tussock the long culms are supported by other culms and also by the roots.

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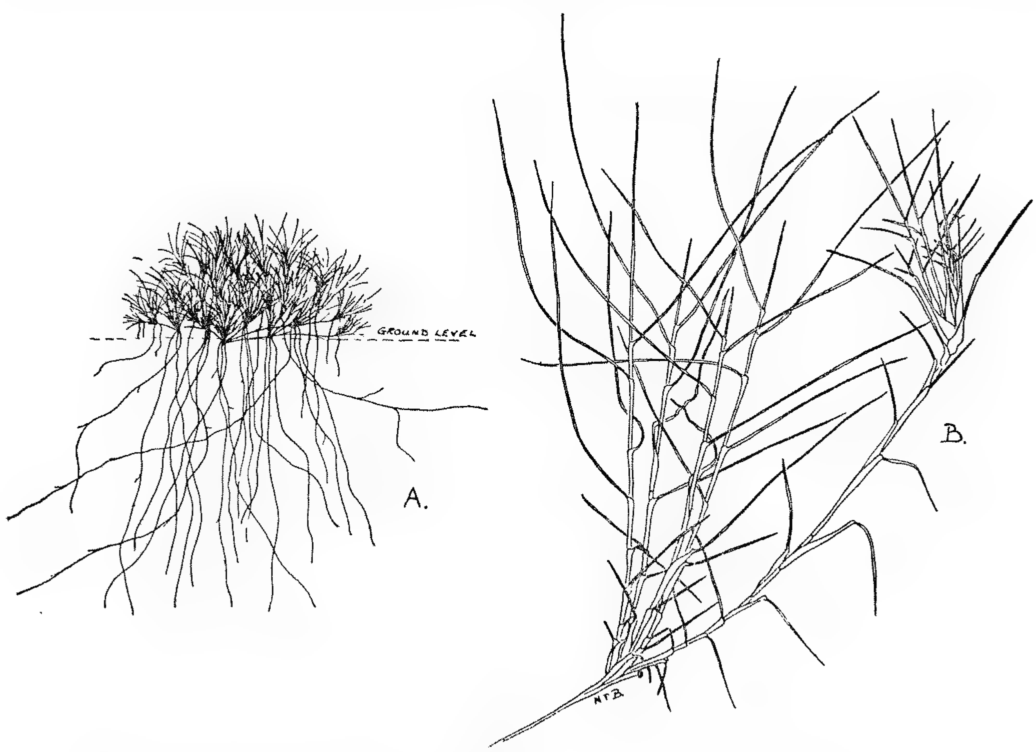
with the development of axillary shoots they may become pushed aside from the culm, when the leaf sheaths may appear to be imbricate and tend to be distichous.

At each node the leaf arises spirally and development is alternately clockwise and anti-clockwise. There is a considerable overlap of the margins of the sheath. At the base the outer margin has a projecting flap of membranous tissue which extends below the node and lies flat against the internode (pl. xxiv, fig. 1-3).

Axillary buds are developed on short internodes and arise on the surface contiguous to the adaxial or inner face of the subtending sheath, *i.e.*, they are axillary but do not arise low in the axil (pl. xxiv, fig. 1-4). The cells which give rise to the bud are apparently laid down before the basal growth of the internode is completed. Thus the bud is carried up away from the leaf base. In *T. pungens*



A. Sketch, showing rooting system in *T. pungens*. From photo.
B. *T. angusta*, showing method of branching. The central culm of the five is the terminal one which would utimately produce a panicle.

when the internode is very short the bud may appear immediately below the node, so that in extreme cases it may seem to develop opposite the next leaf base.

Adventitious roots develop from the same nodes as the axillary shoots (pl. xxiv, fig. 9-11). They have not been observed on nodes along a stolon or on the long internode portion of a culm. The roots push down between the older or surrounding culms towards the ground. They are stiff and prop-like, giving the whole tussock a general rigidity. Since roots are present on a large number of the culms of a current season's growth, the majority of the shoots have their own connection with the soil. The fact that these culms are in direct communication with soil moisture and nutrients must be of importance in so arid a habitat. It is also highly possible that the roots do not function as absorbing organs for any long period. If so, the annular habit may be due to the death of the older roots which would, in turn, mean the death of the corresponding culms.

Roots arise endogenously from the pericycle of the node, in a position nearly opposite to and on the same radius as the mid-vein of the leaf-sheath, *i.e.*, if the root arose a few millimetres higher it would be axillary to the leaf of that node. The course of the root is downwards, so that negative geotropism is demonstrated at an extremely early age. At first the roots, which may arise singly or in pairs, pass through the cortical tissue whose cells proliferate to form a protective pad. This cushion ruptures several millimetres below the node and the root emerges in a position which, in a short internode, may be almost opposite the axillary bud of the node below (pl. xxiv, fig. 9). If the leaf sheath of the node below has not already been pushed aside by curvature of the culm or by the displacement due to developing axillary shoots, then the root will have to force its way through.

Development of roots appears to be closely correlated with the amount of available moisture. Shoots of *T. pungens,* when placed in water for a few days, give rise to roots in the same way as culms on a pot-grown plant during the active growing period. It is believed that roots which are unable to reach the soil owing to a pause in growth, *e.g.*, when the water supply is low, may pass into a dormant state and then continue elongation when conditions again become favourable. However, under glasshouse conditions where plants were grown in pots, this was not observed though a number of roots dried at the tip before reaching the soil.

The root system of tussocks is diffuse and deep. Root excavations, made by Mr. Frank Melville at Warralong Station, Coongan River, in 1941, showed the roots fairly evenly distributed down to three metres, when digging ceased (text fig. A).

The roots are unbranched above the soil and may grow 15-20 cm. or more before reaching the ground if the parent node is high in the tussock. While the root is aerial the edge of the root cap is visible as a small frill around the whitish root tip. Behind, or rather above the root cap, the colour of the root is pale for a length dependent upon the speed of elongation, *i.e.*, with the vigour of growth, while higher still it is pinkish or purple, due to colour in the sclerenchymatous zone of the root cortex. The texture of young roots is almost succulent, but when older the cortical tissues shrink and the surface is wrinkled and pale brown.

Leaves

The leaf is differentiated into well-defined sheath and lamina. As has already been stated, the sheaths are folded around the culm so that the margins overlap. The outer margin has a membranous prolongation which lies flat against the internode below. This flap is always non-vascular (pl. xxiv, fig. 1-3). Its size varies with the position of the leaf on the culm, *i.e.*, whether the internodes are short or long, and also with different species.

The prophyllum is the usual two-nerved structure. One nerve is always longer and better developed than the other. In *T. pungens* (pl. xxiv, fig. 7) the nerves are winged, the wings decreasing in size towards the apex. The nerves have associated bands of chlorenchyma. In other species there are variations such as in *T. brizioides* (pl. xxiv, fig. 8), where there is a definite ligular region with two finger-like projections above. In *T. angusta* there is a similar prolongation of the nerves above a ligule (pl. xxiv, fig. 6). In *T. secunda* the apex has two erect scarious nervate points. In all species the formation is in accordance with Arber's opinion that the prophyllum represents a leaf sheath.(1)

The first leaf above the prophyllum has a more or less normal sheath and a reduced lamina. Above this the leaves are normal in development.

The sheath apparently develops later than the lamina. In young shoots the last leaf visible is erect, projecting from the previous sheath. When dissected out

the leaf is found to have an almost fully lengthened lamina with a delicate growing portion at the base, where a few hairs may or may not be present to indicate the position of the future ligule. If these hairs are not present the sheath cannot be distinguished from the lamina except by microscopic study. Inside the leaf just described are one or two smaller ones. The uppermost internodes to which the latter are attached, are under 2 mm. long. As the sheaths develop they push the lamina up until the ligule emerges above that of the preceding leaf. It then becomes possible for the lamina to bend out from the line of the shoot and to take up its adult position. The bending is the result of the development of a petiolar-like thickening at the base of the lamina (pl. xxiv, fig. 5).

The texture of the sheaths is thin. Their surface is smooth at the base and ribbed above. In some cases, *e.g.*, *T. lanigera* and *T. Fitzgeraldii*, hairs are present. In *T. pungens* resin is developed from the upper portion.

The ligule is similar in all species. It is an even row of cilia developed from the inner epidermis of the top of the sheath. Above the ligule is the petiole-like base of the lamina. This petiole is narrower than the sheath which forms a ridge on either side similar to that in *Phyllostachys aurea* as described by Philipson (4). The epidermis of the ridge, which is referred to hereafter as the *auricular ridge*, commonly bears hairs whose variations are of considerable diagnostic value in the different species. In some cases the line of hairs is continued around behind the petiole, thus emphasising the epidermal origin, *e.g.*, *T. pungens*. In other species, *e.g.*, *T. longiceps* and *T. Wiseana*, the hairs are continued along the margins of the petiole to the base of the lamina. In this case the length of the hairs gradually decreases until only short papillae are present. In *T. lanigera* and *T. Basedowii* the hairs of the auricular ridge are silky woolly. The former species has pubescent sheaths and the hairs of the ridge are better developed than in the latter, where the sheaths soon lose their tomentum. In both species the hairs are continued on to the adaxial surface of the petiole. In *T. pungens* the hairs are usually matted together with resin. In *T. Wiseana* there are long glistening hairs which develop from minute protuberances on the auricular ridge. More widely spread groups occur along the petiole and the base of the lamina. In the type specimen the hairs continue along the blade for several centimetres, but in *T. Wiseana* var. *breviseta* [1] N. T. Burbidge the hairs are not so well developed. On the plant the hairs were placed with their long axes parallel to the margin of the leaf, so that they were not at all conspicuous. On drying the hairs stood out as shown in the diagram (pl. xxv, fig. 4 a). In *T. brizioides* the auricular hairs are woolly like those of *T. lanigera* and *T. Basedowii*, but the sheaths are glabrous. In *T. irritans* there are stiff glistening hairs longer than those of the ligule. The line of hairs extends down the margin of the sheath, and a shorter series is found passing up the petiole to the lamina. Stiff hairs are also found in *T. Fitzgeraldii* and *T. longiceps* (pl. xxv).

With regard to *T. angusta* the position is not altogether satisfactory. It was necessary in the taxonomic paper to group specimens with differing auricular ridge characters. One specimen had long hairs and another woolly ones. However, in the majority of specimens, including the type, the auricular ridge is similar to that in *T. longiceps*.

T. secunda has the most peculiar development of all, the ridge having grown out into a fringed structure with scabrous margined lobes. This structure includes continuations of three of the lateral nerves of the sheath (pl. xxiv, fig. 5; and xxv, fig. 5 a and 5 b). In the other species the lateral nerves either bend below the ridge and enter the petiole or they die out, *e.g.*, *T. Fitzgeraldii*.

Above the petiole the lamina has the two halves folded together dorsally. The effect in a dry leaf produces a terete structure with a deep groove on one

side. In fresh or growing material the blade is more or less open, *i.e.*, V-shaped in cross section compared with U-shaped when dry. The more heavily sclerised the general tissue the less open the lamina when fresh. Except in *T. pungens*, both sides of the lamina are deeply but minutely grooved. In all species the lamina is twisted or respinate to some degree.

Panicles

The mature panicle is typically an open structure, but in *T. angusta* and *T. secunda* the lateral sub-branches are reduced so that the spikelets are arranged as one-sided spikes or racemes lateral to the main axis.

The panicle is at first enclosed in the uppermost leaf sheath, which may be slightly enlarged. When the panicle first emerges the branches are erect, so that there is a compact appearance. But during anthesis swellings develop at the bases of the branches. These force the panicle open (pl. xxii, fig. 4). Similar structures have been described in other grasses (1). In pot-grown material of *T. pungens*, which turned out to be self-sterile, the spikelets were markedly protandrous. The pulvini were conspicuous during the early stages when the pollen was shed, and gradually decreased in size until soon after the stigmas had shrivelled the panicle branches were once more upright. The photo shows a panicle midway between the pollen shedding and stigmatic states. Whether protandry occurs in other species is not known. In *T. brizioides* there are hairs associated with the pulvini.

The spikelets, which have several fertile florets, have been described and figured in the taxonomic paper.(1) In *T. pungens*, *T. lanigera* and *T. Basedowii* the lemmas are deeply three lobed, in *T. Wiseana* less so, and in the remaining species the lemma is merely tridentate at the apex. In the portions of the lemmas exposed to the light the nerves have associated strands of chlorenchymatous tissue on either side. These green strips are conspicuous in the lobes of the first three species, and in the upper part of the lemmas in the remainder. Chlorenchyma strands are also associated with the nerves of the palea, but have not been observed on the glumes except in *T. lanigera*.

Summary

A general description of the morphology of the various species has been given. The plants show features which are of interest to the ecologist and the taxonomist, as well as to the anatomist.

The method of branching and of root formation display a high degree of specialisation, which is illustrated further in the structure of the leaves.

A fuller discussion will be given in the sections on the internal anatomy.

Acknowledgments

Part of this work was done at the Institute of Agriculture, University of Western Australia, under a research grant from the Council for Scientific and Industrial Research. It was completed at the Waite Agricultural Research Institute, University of Adelaide. The writer wishes to express her appreciation of the facilities granted.

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Fig. 1

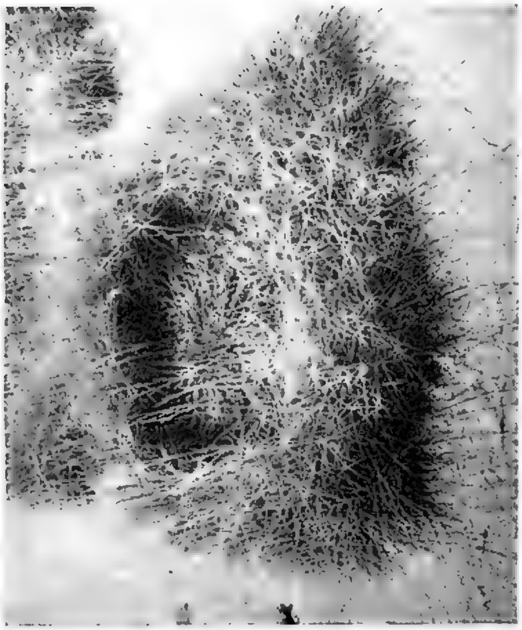


Fig. 2

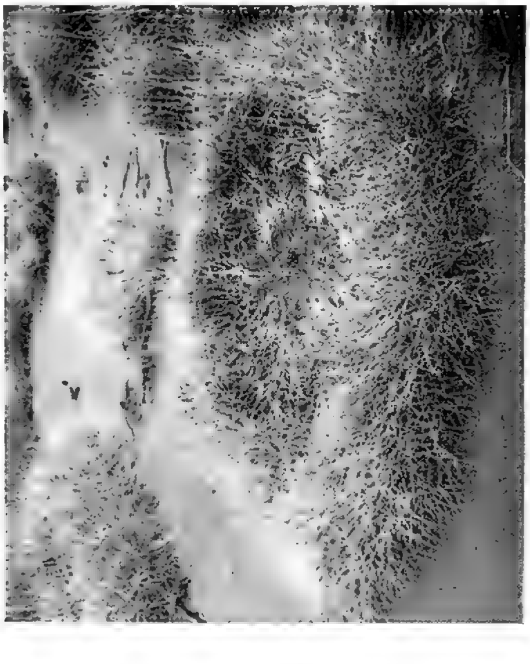


Fig. 3

Fig. 4

Stages in the formation of an annular tussock, *Triodia* sp.

Photos by Mr. C. P. Mountford

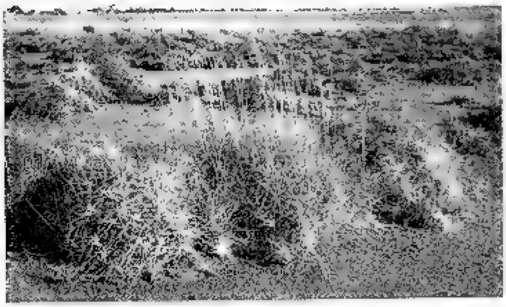


Fig. 1 *T. angusta*

Fig. 2 *T. secunda*

Fig. 3 *T. brizioides*

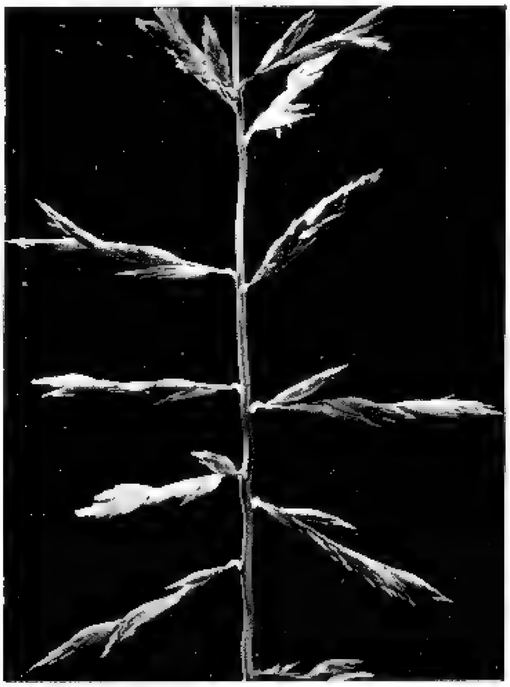
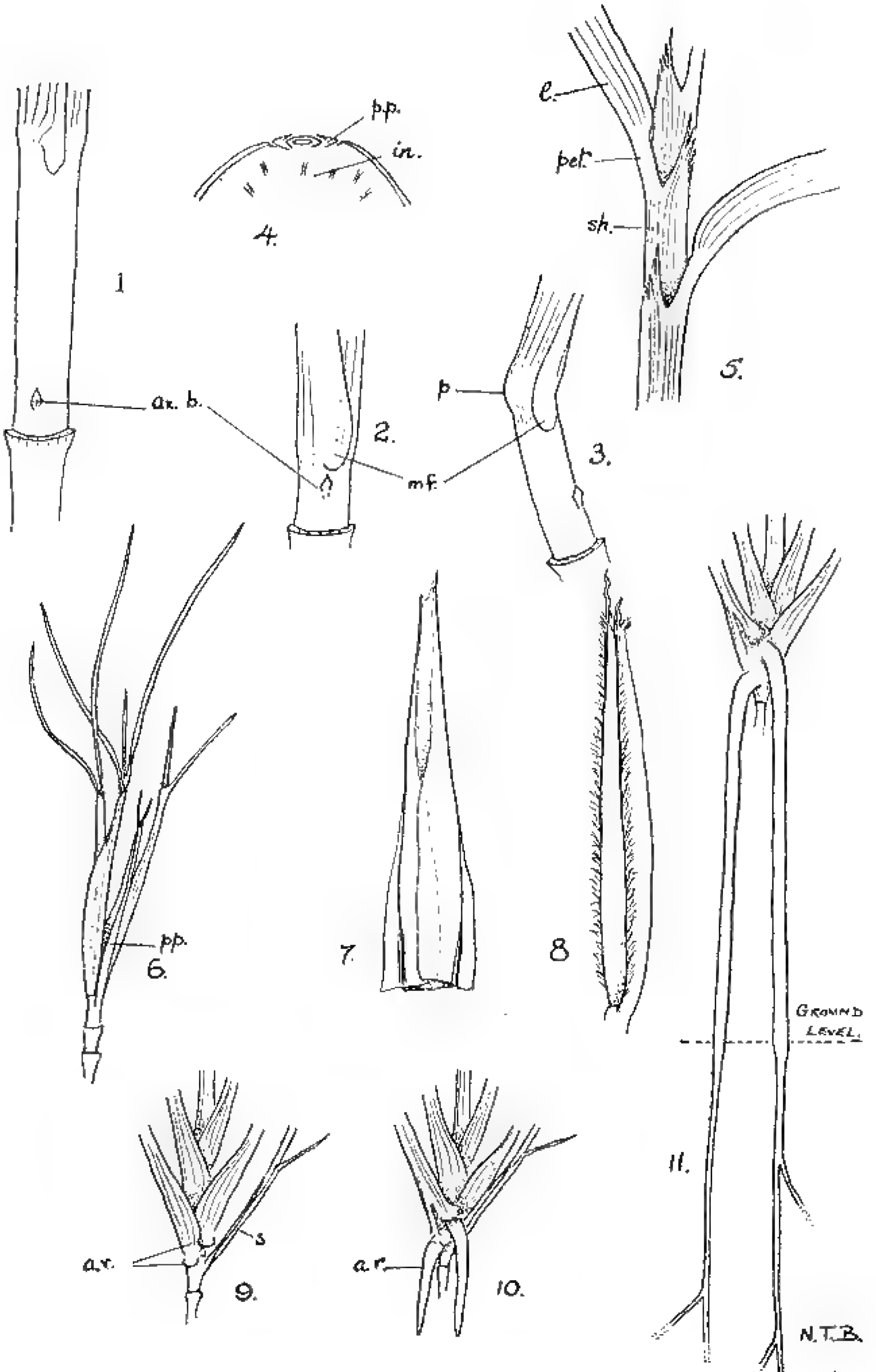


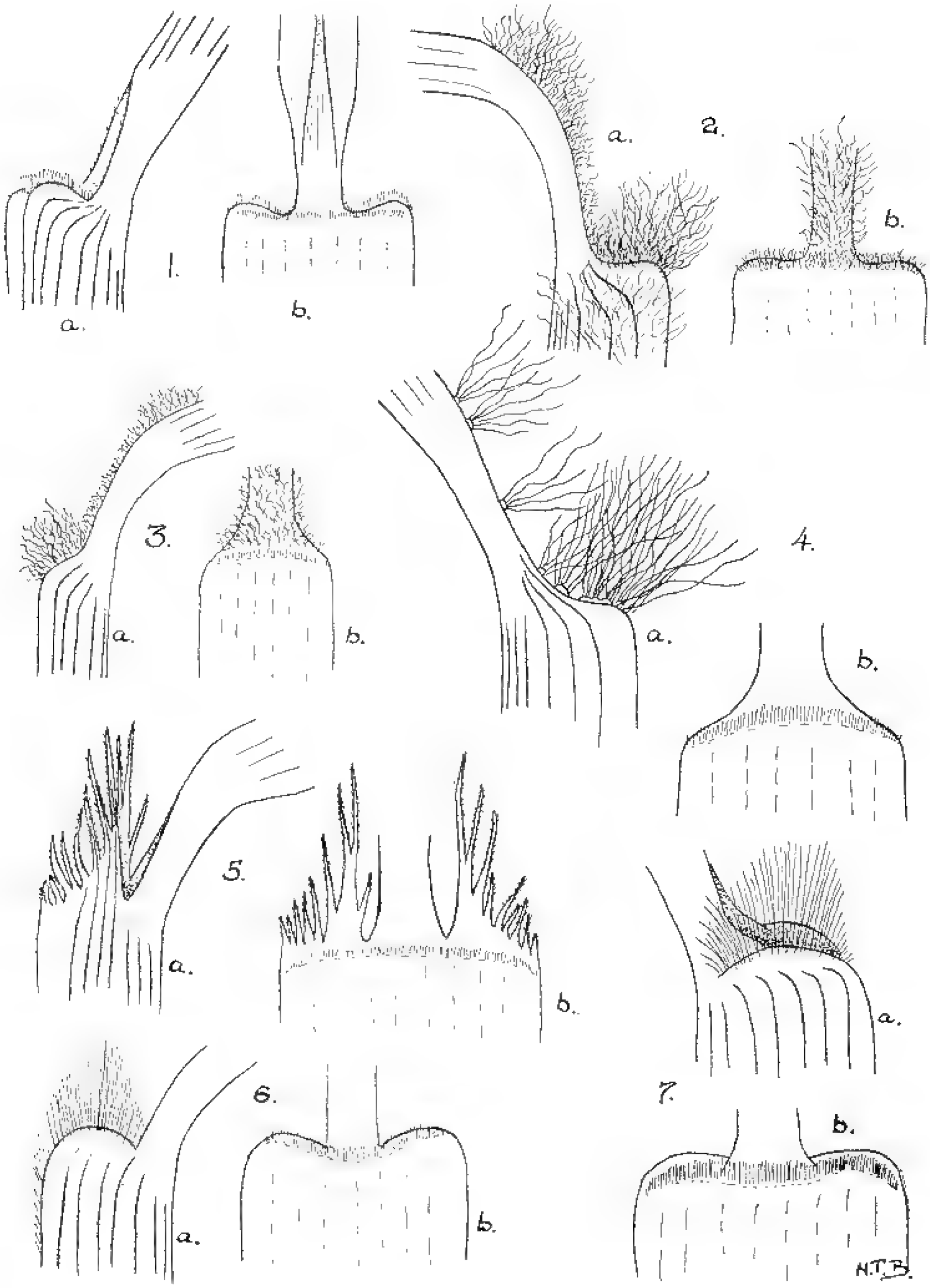
Fig. 4 *T. pungens.* Panicle with pulvini at bases of branches. Nat. size

A. *T. pungens*, culms from stoloniferous form.
B. *T. longiceps*, showing method of branching.
C. *T. lanigera*, showing method of branching.



1, *T. longiceps*, internode, showing axillary bud and marginal lobe. 2 and 3 *T. pungens*, ditto. 4, diagram showing position of bud against internode. 5, *T. secunda*, petiole base of lamina. 6, *T. angusta*, shoot with two axillaries, one with leaf removed to show position of shoot on internode, also prophyllum. 7, *T. pungens*, prophyllum. 8, *T. brizioides*, prophyllum. 9, 10 and 11, development of adventitious roots—semi-diagrammatic.

ax. b, axillary bud; mf, marginal lobe; p, pulvinus; pp, prophyllum; in, internode; l, lamina; pet, petiole; sh, sheath; ar, adventitious root; s, shoot. 1, 2, 3, 5, 7 and 8, all x 4; 4, x 15; 6, 9, 10 and 11, approx. nat. size.



1, *T. longiceps*. 2, *T. lanigera*. 3, *T. brizioides*. 4, *T. Wiseana*. 5, *T. secunda*. 6, *T. Fitzgeraldii*. 7, *T. pungens*

All showing ligule and auricular ridge—a, lateral view; b, adaxial view; all x 8.

ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA

BY J. M. BLACK, A.L.S. (READ 11 OCTOBER 1945)

Summary

Loranthus diamantinensis, nov. sp. Glaber; folia opposita, oblonga, crassa, obtusa, 4-10cm longa, 12-20mm lata, nervis 3-5 prominentibus longitudinalibus inter se reticulatis, basin versus angustata, subsessilia; folia superiora minora, lanceolata, trinervia; flores terni, omnes pedicellati, umbellam simplicem (?) formantes, pedunculo tantum 2mm longo; perianthium circa $3^1/_2$cm longum, in tubo rubrum, superne subviride; fructus ovoideus, laevis.
Minnie Downs, Diamantina River. Resembles *L. dictyophlebus*, F. v. M., in the leaf, but not in the inforescence; besides *dictyophlebus* is a coastal species of Eastern Australia. The specimen from Minnie Downs is single and imperfect, but appears to have distinguishing specific characters.

ADDITIONS TO THE FLORA OF SOUTH AUSTRALIA

No. 43 [1]

By J. M. Black, A.L.S.

[Read 11 October 1945]

Loranthaceae

Loranthus diamantinensis, nov. sp. Glaber; folia opposita, oblonga, crassa, obtusa, 4-10 cm. longa, 12-20 mm. lata, nervis 3-5 prominentibus longitudinalibus inter se reticulatis, basin versus angustata, subsessilia; folia superiora minora, lanceolata, trinervia; flores terni, omnes pedicellati, umbellam simplicem (?) formantes, pedunculo tantum 2 mm. longo; perianthium circa 3½ cm. longum, in tubo rubrum, superne subviride; fructus ovoideus, laevis.

Minnie Downs, Diamantina River. Resembles *L. dictyophlebus,* F. v. M., in the leaf, but not in the inflorescence; besides *dictyophlebus* is a coastal species of Eastern Australia. The specimen from Minnie Downs is single and imperfect, but appears to have distinguishing specific characters.

Chenopodiaceae

Chenopodium insulare, nov. sp. Plantula procumbens, glabra; rami ascendentes; folia parva, alterna, conferta, subcrassa, subsessilia, oblanceolata, 4-7 mm. longa, 2-2½ mm. lata, inferiora deflexa; flores 1-3 in axillâ; perianthium depressum, glabrum, lobis 5 obtusis et 5 staminibus; stylus brevis crassus, ramis duobus; fructus horizontalis, perianthii lobis fere occultus.

South Pearson Island, 3 Jan. 1923; *T. G. B. Osborn.* Differs from *Ch. pseudomicrophyllum,* Aellen (*Ch. microphyllum,* F. v. M.), in its glabrous (non-mealy) character, its smaller, narrower, thicker leaves, and very short broad petioles, the flowers very few in the axils and never forming spikes.

Atriplex cordifolia, nov. sp. Annua, recta, glabra, 40-60 cm. alta, caule ramisque rigidis, albidis; folia ovato-lanceolata, sinuato-dentata, crassiuscula, cinerea, papillosula, base sessilia et cordata, 7-15 mm. longa, 6-8 mm. lata; flores in axillis glomerati, glomerulo summo androgyno, inferioribus masculis; bracteolae fructiferae fere ut in *A. Muelleri,* sed vix denticulatae, subrhomboideae, 3 mm. longae et latae, leviter trinerves.

Sandhills east of Lake Eyre, Aug. 1939; *Simpson Desert Expedition.*

Near *A. Muelleri* in the fruit, but differs in the smaller, thicker, paler and sessile-cordate leaves.

Amaranthaceae

Ptilotus Gaudichaudii (Steud.) nov. comb.—*Trichinium corymbosum,* Gaudich (1826) non *Ptilotus corymbosus,* R. Br. (1810) nec *Trichinium corymbosum* (R. Br.) Spreng. (1825); *T. Gaudichaudii,* Steud. (1841); *Ptilotus hemisteirus,* F. v. M. (1864).

Myrtaceae

Melaleuca oraria, nov. sp. Frutex erectus, glaber, valde ramosus, ramulis summis longis, erectis, cortice palido; folia alterna, conferta, cinerea, crassa, obtusa, lineari-lanceolata, plano-convexa, 3-5 mm. longa, suberecta, infra glandulis

(1) The last "Additions to the Flora of South Australia" in the Trans of the Society, **67,** (1), 1943, should be No. 42 instead of No. 41.

immersis biserialibus instructa; flores sessiles, in ramulis anni praeteriti crescentes atque in parvos glomerulos et spicas cylindricas collecti; torus 2 mm. longus; sepala deltoidea, dimidio breviora; petala alba, circa 1½ mm. longa lataque; unguiculae staminales petala subaequantes, earum filamenti 7-13 albi; fructus globoso-truncati, suberosi,, leviter 5-angulati, arcte sessiles, 4-5 mm. lati, interrupte spicati.

Encounter Bay; Rocky River (Kangaroo Island); Beachport, Yallum (South-East).

Near *M. brevifolia,* Turcz, a Western Australian species. Formerly placed under *M. fasciculiflora,* Benth. Differs from *M. brevifolia* in the ashy leaves, the deltoid sepals, the petals scarcely longer than the sepals, the filaments usually fewer, the flowers growing chiefly on the previous year's wood and the thick somewhat 5-angled fruit.

PRIMULACEAE

Samolus Valerandi, L. This cosmopolitan plant has been found near Ernabella, in the Musgrave Ranges, for the first time in South Australia, and several hundred miles from its nearest recorded habitat. First discovered in 1944 by Mr. L. B. Young, better specimens were obtained later through the Rev. J. R. B. Love, of the Presbyterian Mission at Ernabella. Also grows in New South Wales and Queensland.

LEGUMINOSAE

Acacia euthycarpa, nov. comb. Phyllodiis capitulisque illis *A. calamifoliae* similibus, sed phyllodiis arcte trinervibus; legumine margine stricto (inter semina non constricto), funiculo semen fere omnino cingente.—*A. calamifolia* Sweet var *euthycarpa,* J. M. Black.

Northern Flinders Range to Far North.

ON THE BEHAVIOUR OF BARIUM IN SILICATE ANALYSIS

BY E. R. SEGNIT (READ 11 OCTOBER 1945)

Summary

During the examination of barium-rich gneisses from Broken Hill, difficulties were encountered in the ordinary routine method of silicate analysis, because of the presence of large amounts of barium.

Owing to the rarity of barium silicate or alumino-silicate minerals, silicate rocks are seldom met with which contain more than a fraction of a per cent. BaO. In the average rock or mineral analysis, therefore, no troubles are experienced by the presence of barium. It passes completely through the analysis, the double precipitation of calcium oxalate being more than sufficient to keep it in solution, and similarly through the magnesia precipitation. However, when large amounts of barium are present, it is not so easily eliminated.

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Owing to the rarity of barium silicate or alumino-silicate minerals, silicate rocks are seldom met with which contain more than a fraction of a per cent. BaO. In the average rock or mineral analysis, therefore, no troubles are experienced by the presence of barium. It passes completely through the analysis, the double precipitation of calcium oxalate being more than sufficient to keep it in solution, and similarly through the magnesia precipitation. However, when large amounts of barium are present, it is not so easily eliminated.

Results of Laboratory Experiments

As the behaviour of the barium was not known, precipitations of known amounts of barium were carried out under conditions simulating those which would be met with in the analyses of the rocks. The barium oxalate was generally ignited to carbonate. The oxalate is converted to carbonate at quite a low temperature, while the carbonate may be safely ignited over a Meker burner for 10 minutes without noticeable decomposition. For comparison, duplicate precipitations were in some cases redissolved and reprecipitated as the sulphate. There seems to be a small loss in this procedure.

The following results obtained from the precipitation of known amounts of barium are:—

I. Barium was precipitated at various pH values by adding oxalic acid and neutralizing with ammonium hydroxide. Volume of solution about 150 cc.

No. Test	pH Approx.	Weighed as	Other Const. present	BaO present	BaO found	BaO loss
1	6·8	$BaCO_3$	—	·0916	·0873	·0043 gm.
2	6·8	$BaSO_4$	—	·0916	·0867	·0049
3	7·6	$BaCO_3$	—	·0916	·0873	·0043
4	7·6	$BaSO_4$	—	·0916	·0861	·0055
5	4·6	$BaSO_4$	—	·0916	·0833	·0084
6	7·6	$BaCO_3$	—	·0183	·0156	·0027
7	7·6	$BaCO_3$	5gm NH_4Cl	·0916	·0765	·0151
8	7·6	$BaCO_3$	„	·0765	·0570	·0195 (= No. 7 reprecip.)
9	7·6	$BaCO_3$	„	·0183	·0001	·0182
10	7·6	$BaCO_3$ + CaO	5gm NH_4Cl ·1089g CaO	·0916	·0751	·0165
11	7·6	$BaCO_3$ + CaO	5gm NH_4Cl ·1089g CaO	·0751	·0357	·0394 (= No. 10 reprecip.)
12	7·6	$BaCO_3$ + CaO	5gm NH_4Cl ·1089g CaO	·0183	·0033	·0150

II. Solution made up to 400 cc. and barium precipitated with H_2SO_4.

13	—	$BaSO_4$	5gm NH_4Cl	·0916	·0915	·0001

III. Solution made up to 400 cc. and barium precipitated with ammonium phosphate.

14	—	$Ba_3(PO_4)_2$	5gm NH_4Cl	·0916	·0800	·0116
15	—	$Ba_3(PO_4)_2$	„	·0183	·0018	·0165

Some of the above results are not perfectly concordant, but they serve to indicate the behaviour of the barium. If large quantities of barium are present, much will remain with the calcium oxalate, even after a double precipitation.

Procedure adopted for Analysis of Barium-Silicate Minerals

With the one gram sample usually taken in a rock analysis, complete separation of barium and calcium as oxalates cannot be ensured if more than 4% or 5% BaO is present. Smaller samples can, of course, obviate this difficulty. However, some of the rocks being examined contained up to 15% BaO. In this case, it was found simplest to ignite the precipitate to $CaO + BaCO_3$, dissolve in a small amount of hydrochloric acid, and precipitate the barium as sulphate, making sure the volume was great enough to keep calcium in solution. The CaO, after ignition of $BaSO_4$, was determined by difference.

In the analysis of the barium-containing minerals, 50-100 milligrams were used. In this case the actual amount of BaO present was small enough to be separated completely by the use of relatively large volumes of solution; the solubility of the calcium oxalate had a noticeable effect on the CaO percentage, with the small samples used. Similar considerations apply to the precipitation of magnesia, as indicated by tests 14 and 15. It is simplest here to remove barium as sulphate before precipitating the magnesia.

A further complication arose by the precipitation of barium with the ammonia precipitate. It was found during the several analyses carried out, that up to 10 milligrams of BaO in a one-gram sample containing 15% BaO remained with the iron, alumina, etc., after a double precipitation. This was collected and determined after the pyrosulphate fusion. No barium was found in the silica.

It can be seen, then, that with the presence of much barium in a silicate rock or mineral, care must be taken to ensure the non-contamination of other constituents—from the ammonia precipitate it can be recovered and weighed as sulphate after the pyrosulphate fusion; from calcium by solution of ignited precipitate in HCl, and precipitation at sulphate; and from magnesia by elimination as $BaSO_4$ before addition of ammonia and ammonium phosphate.

Behaviour of Barium in the Case of an Actual Rock Analysis

An analysis of one of the rocks which contains 14·72% BaO is appended. In this rock barium is present as a variety of the rare barium feldspar celsian, which, on separation from the rock was found to contain 25·8% BaO.

	I	II	III		I	II	III
SiO_2 -	49·10		49·10	Na_2O -	1·52		1·52
TiO_2 -	·17		·17	K_2O -	·71		·71
Al_2O_3 -	25·43	1·0	26·39	H_2O+	·35		·35
Fe_2O_3 -	·04		·04	H_2O-	·08		·08
FeO -	·19		·19	P_2O_5 -	·06		·06
MnO -	·005		·005	S -	·04		·04
MgO -	·08	4·6	2·62	Cl	·04		·04
CaO -	7·65	8·8	19·03				
BaO -	14·72		—		100·185		100·345

Column I gives the correct analysis; II shows the distribution of the BaO among the other constituents; III gives the analysis as it appeared before allowing for the barium content of the rock. It is of interest that the lower conversion factor for MgO (as against that for BaO) balanced the extra weight due to the carbonate radical of the $BaCO_3$ in the calcium precipitate, the total remaining unchanged.

OBITUARY NOTICES

JAMES DAVIDSON

Summary

The death on 13 August 1945 of Professor James Davidson came as a severe blow to the Fellows of the Society and to many other colleagues and friends. His death was a profound loss to Australian biological science.

HORACE EDGAR DUNSTONE, M.B., B.S.

Summary

Horace E. Dunstone passed away on 13 July after a brief illness. The son of Mr John Dunstone, of Beetaloo, South Australia, he received his earlier education at Le Fevre Peninsula School and Largs Bay College.

JAMES THOMAS WILSON

Summary

Professor James Thomas Wilson, M.B. (Edin.), M.D., Ch.M. (Sydney), M.A. (Cantab.), LL.D. (Edin), F.R.S., FZ.S., an Honorary Fellow of the Royal Society of South Australia since the year 1894, passed away in September last. At the time of his death he was Emeritus Professor of Anatomy in the University of Cambridge.

OBITUARY NOTICES

JAMES DAVIDSON

The death on 13 August 1945 of Professor James Davidson came as a severe blow to the Fellows of the Society and to many other colleagues and friends. His death was a profound loss to Australian biological science.

Davidson was born in Cheshire, England, in 1885. He graduated B.Sc. from Liverpool University in 1908. While an undergraduate he was deeply influenced

JAMES DAVIDSON, D.Sc.

by the breadth of view of W. A. Herdman's lectures in Natural History and by R. Newstead who lectured in Applied Entomology. Major (later Sir) Ronald Ross, with whom Davidson was later associated in anti-malarial work, was at this time Dean of the Liverpool School of Tropical Medicine.

In 1910 Davidson graduated M.Sc. He held the Wolfe Barry Research Studentship at the Imperial College of Science and Technology, and was later awarded a research scholarship in Zoology by the Ministry of Agriculture. During

his post-graduate years he began his studies on the biology of aphides and their feeding mechanisms. He was associated with L. E. Robinson in the production of a beautifully illustrated monograph entitled "The Anatomy of *Argas persicus*," which has become a classic. His work in these subjects gained him the degree of D.Sc. of Liverpool in 1915. During 1914 until the outbreak of war, Davidson worked in Berlin at the Royal Biological Institute for Agriculture and Forestry, Dahlem.

When war broke out in 1914 Davidson enlisted with the Royal Fusiliers, but soon received a commission in the Royal Irish Rifles. He was transferred to the War Office, London, for special entomological duties. At first he was concerned with scabies and louse infestation of soldiers on the Western Front. Later he took part in the campaign in the Sinai Desert, where he made a notable contribution to the control of flies and dysentery. He was mentioned in dispatches for this work.

In 1919, after his demobilisation from the Army, he spent six months in Italy, working in the laboratory of the famous Professor A. Berlese at Florence, and also with F. Silvestri at Portici.

In the same year he was appointed Chief Assistant in Entomology at the Rothamsted Agricultural Experiment Station. Here he continued his work on aphides; in particular he studied the complex problems of polymorphism and castes, and the curious phenomenon of migration and alternation of hosts which was known to occur in some species. He continued his observations of their feeding processes and was able to demonstrate the path taken by the mouthparts through the tissues. His papers on these subjects, particularly a monograph entitled "British Aphides," are well known today.

During these investigations an incidental observation provided what has since proved to be a very fruitful clue. Davidson was growing broad bean plants in water culture solutions, mainly to observe the influence of added chemicals on the aphis population. He noticed that plants which had received a small quantity of boric acid grew more strongly than the others. This clue was followed up by his colleagues in Plant Physiology and led to a great deal of pioneer work on "trace elements."

In 1928 Davidson came to Adelaide to take charge of the Entomology Department of the new Waite Agricultural Research Institute. He brought an open mind to bear upon the problems in this new province. He was quick to perceive that in a climate such as that in South Australia the physical environment has an important influence on the distribution and abundance of insect species. For his first major investigation in Australia he chose the lucerne flea (*Smynthurus viridis* L.), a springtail which sometimes does severe damage to pastures and lucerne in South Australia. After a painstaking investigation he was able to define the "conditions" of temperature and soil moisture for *S. viridis* to survive and thrive.

When he came to interpret the weather records in terms of this knowledge with a view to understanding the distribution and possible range of *S. viridis*, Davidson found that the standard meteorological readings were not in a form suitable for immediate use by the ecologist. After much investigation, cogitation and discussion, Davidson developed the idea of calculating a figure for "evaporation" using records of saturation deficit and evaporation from a free water surface. The value for "evaporation" was then divided into the recorded value for rainfall to give a rainfall/evaporation ratio, which could be used as an index of "adequate" soil mixture. For *S. viridis* the moisture in the environment was considered favourable when this ratio (based on monthly values) was of the order of 1. South Australia (and later Australia) was mapped to show the

number of months in each district during which P/E ratio exceeded 1; and from this were deduced the limits of the areas more or less favourable to *S. viridis*.

This pioneer work led Davidson on to a consideration of the climatology of Australia. For several years he devoted himself to this study, and, after several preliminary papers, eventually published a map showing the "bioclimatic zones" of Australia. The zones in this map was based on the length of the period (in months) for which the P/E ratio exceeded 0·5, and a distinction was made as to whether these months occurred during the cooler or the hotter part of the year. Davidson's work on climatology has been a stimulus to workers in animal and plant ecology in Australia and abroad.

Still retaining his vivid interest in the influence of the physical environment, Davidson was next attracted to the problem of the relationship between temperature and the rate of development of insects (and other arthropods). Working mostly with data for insect eggs—in some cases with data determined by members of his own department, in others with carefully determined data from overseas workers—he was able to show that the conception, long held by most biologists, that the rate of development is proportional to temperature over the favourable temperature range is inadequate. Also he showed that the various types of curvilinear relationships suggested by a number of authors were less adequate than the Pearl-Verhulst logistic curve. In Davidson's hands the logistic curve became a sensitive tool, and the several papers which he published on this subject show what a very good fit to observed data may be got when this curve is used.

The logistic curve was deduced by Verhulst and modified by Pearl to express first the growth of an experimental population in an environment kept artificially constant in the laboratory, and then the growth of human populations. A number of workers had repeated Pearl's work, but Davidson sought to apply the conception of the logistic curve to the growth of insect populations in Nature. It was characteristic that when the complexities of the problem first defeated him, he set it aside temporarily while he studied the growth of sheep populations in Australia—a somewhat simpler problem. Fortified with the knowledge he had gained in these studies, he returned to the original problem. He was able to recognise and abstract a number of the factors which interfere with the simple expression of the logistic law in natural populations. Most important among these is the shortness of the favourable season each year for insects living in temperate climates, and the fact that many insects survive the unfavourable season by an adaptation in one particular stage. This means that the insects enter the favourable season for multiplication and population growth all in the same stage of their life history. These facts were discussed by Davidson in a paper in the Australian Journal for Experimental Biology and Medical Science, vol. 22.

Ever since 1932 a daily record of the number of *Thrips imaginis* Bagn. in roses has been kept at the Waite Institute. Davidson was aware of the great value of these data for an investigation on the influence of weather on the growth and decline (season to season) of a natural population. At the time of his death a long and laborious analysis, based on the methods of R. A. Fisher's classical study of the yields of wheat from Broadbalk, was nearing completion.

Davidson was a prominent Fellow of the Society from 1929 until his death. He was a member of the Council from 1932 to 1935; and President during 1937-38. He also took an active part in the corporate and social life of the community and of the University of which he was a distinguished member. Since 1935 he had held the position of Waite Professor of Entomology, thus occupying the first and only Chair of Entomology in Australia.

James Davidson will be sorely missed by his colleagues and friends. His published works stand as a monument to his contribution to science. But only

his colleagues can know of the less tangible, but no less great, contribution to progress which he made by virtue of his personality. In all things he had the most ardent passion for truth and accuracy. Nothing was more distasteful than "woolliness," and all who worked with him were inspired by the standards which he set. We can all bear witness too, to the fine humane qualities which marked his intercourse with his fellows. His mind and heart were ever open to receive the ideas and feelings of those around him; and charity seemed to be natural to him; in twelve years of close association, I cannot once recall an uncharitable word.

The following is a list of the technical papers published by James Davidson:

1913 The structure and biology of *Schizoneura lanigera* Hausmann, or woolly aphis of the apple tree. Quarterly Journal of Microscopical Science, **58**, (4), 653-701.

1913 The anatomy of *Argas persicus* Robinson, L. E., and Davidson, J. Pt. i., Parasitology, **6**, 6, (1), 20-48; pt. ii, *ibid.*, **6**, (3), 217-256; pt. iii, *ibid.*, **6**, (4), 382-424.

1914 Ueber die Wirtpflanze von *Aphis rumicis* L. Zeits. wissen. Insektenbiol., **10**, (5), 189-190

1914 The host plants and habits of *Aphis rumicis* Linn., with some observations on the migration of, and infestation of, plants by aphides. Ann. Appl. Biol., **1**, (2), 118-141.

1914 Ueber die Wirtflauze von *Aphis rumicis* L. Zeits. wiss. Insektenbiol., **10**, (5), 189-190.

1914 On the mouthparts and mechanism of suction in *Schizoneura lanigera* Haus. Trans. Linn. Soc. Lond. Zool., **32.**

1918 Some practical methods adopted for the control of flies in the Egyptian campaign. Bull. Entom. Res., **8**, 297-309.

1921 Biological studies of *Aphis rumicis* Linn. Bull. Entom. Res., **12**, 81-89.

1921 Biological studies of *Aphis rumicis* Linn. Ann. Appl. Biol., **8**, 51.

1921 Biological studies of *Aphis rumicis* L. A—Appearance of winged forms. B—Appearance of sexual forms. Sci. Proc. R. Dublin Soc., **16**, (25), 304-322.

1922 Biological studies of *Aphis rumicis* Linn. Reproduction of varieties of *Vicia faba* Fisher, (R. A.)—A statistical appendix. Ann. Appl. Biol., **9**, (2), 135-145.

1923 Biological studies of *Aphis rumicis* Linn. The penetration of plant tissues and the source of food supply of Aphids. Ann. Appl. Biol., **10**, (1), 35-54.

1923 The penetration of plant tissues and source of the food supply of Aphids. Rept. Int. Con. Phytopath & Econ. Ent., Holland, 72-74.

1924 Factors which influence the appearance of the sexes in plant lice. Science, **59**, (1,529), 634.

1925 The bean aphis. Jour. Minist. Agric., **32**, (3), 234-242.

1925 A list of British aphides. 8vo, xi + 176 pp. London, Longmans, Green & Co.

1925 Biological studies of *Aphis rumicis* Linn. Factors affecting the infestation of *Vicia faba* with *Aphis rumicis*. Ann. Apply Biol., **12**, (4), 472-507.

1926 The sexual and parthenogenetic generations of the life-cycle of *Aphis rumicis* L. Verh. III Internat. Ent.-kongr., Zürich, 1925, **2**, 452-457.

1927 The biological and ecological aspect of migration in aphids. Sci. Prog., **21**, (84), 641-658; **22**, (85), 57-69.

1927 On some aphides infesting tulips. Bull. Ent. Res., **18**, (1), 51-62.

1929 On the occurrence of the parthenogenetic and sexual forms in *Aphis rumicis* L., with special reference to the influence of environmental factors. Ann. Appl. Biol., **16**, 104-134.

1929 Report on the occurrence of the woolly pear aphis (*Eriosoma lanuginosum*, Hartig; *E. pyricola*, Baker and Davidson). Jour. Dept. Agric. S. Aust., 32, (9), 798-799.

1929 The internal condition of the host plant in relation to insect attack, with special reference to the influence of Pyridine (by Henson, H., and Davidson, J.). Ann. Appl. Biol., **16**, (3), 458-471.

1930 Description and bionomics of *Frankliniella insularis* Franklin (Thysanoptera), Davidson, J., and Bald, J. G. Bull. Ent. Res., **21**, (3), 365-385.

1930 White grubs. Jour. Dept. Agric. S. Aust., **34**, (3), 224-227.

1931 Insects observed on crops in South Australia during period June 1928 to June 1930. Jour. Dept. Agric. S. Aust., **34**, (7), 741-745.

1931 The influence of temperature on the incubation period of the eggs of *Smynthurus viridis* L. (Collembola). Aust. Jour. Exp. Biol. Med. Sci., **9**, (2), 143-152.

1932 Resistance of eggs of Collembola to drought conditions. Nature, **129**, (3,267), 867.

1932 Some factors affecting oviposition of *Smynthurus viridis* L. (Collembola). Aust. Jour. Exp. Biol. and Med. Sci., **10**, (1), 1-16.

1932 On the viability of the eggs of *Smynthurus viridis* L. (Collembola) in relation to their environment. Aust. Jour. Exp. Biol. and Med. Sci., **10**, (2), 66-88.

1932 Insects observed on crops in South Australia during the period June 1930 to June 1932. Jour. Dept. Agric. S. Aust., **36**, (3), 283-286.
1933 The environmental factors affecting the development of the eggs of *Smynthurus viridis* L. (Collembola). Aust. Jour. Exp. Biol. and Med. Sci., 11, (1), 9-23.
1933 On the control of the "Lucerne Flea (*Smynthurus viridis* L.) in lucerne in South Australia. Jour. Dept. Agric. S. Aust., **36**, (9), 994-1,006.
1933 The distribution of *Smynthurus viridis* L. (Collembola) in South Australia, based on rainfall, evaporation and temperature. Aust., J. Exp. Biol. Med. Sci., **11**, (2), 61-66.
1933 A method for obtaining samples of the population of Collembola (Symphyleona) in pastures. Davidson, J., and Swan, D. C. Bull. Ent. Res., **24**, (3), 351-352.
1933 The species of blowflies in the Adelaide district of South Australia and their seasonal occurrence. Jour. Dept. Agric. S. Aust.. **36**, (10), 1,148-1,153.
1933 The "Lucerne Flea" problem in South Australia. Jour. Dept. Agric. S. Aust., **37**, (3), 291-297.
1934 The "Lucerne Flea" *Smynthurus viridis* L. (Collembola) in Australia. Bull. Counc. Sci. Ind. Res. Aust., (79).
1934 The wandering grasshopper. Jour. Dept. Agric. S. Aust., 37, (11), 1898.
1934 Control methods used against locusts and grasshoppers. Jour. Dept. Agric. S. Aust., **38**, (5), 619-624.
1935 Insects observed on crops in South Australia during period June 1932-June 1934. Jour. Dept. Agric. S. Aust., 38, (8), 998-1,003.
1935 The apple-thrips (*Thrips imaginis* Bagnall). Jour. Coun. Sci. Industr. Res. Aust., **8**, (3), 234-236.
1935 Rainfall-evaporation ratio in relation to locust and grasshopper outbreaks. Nature. 136, 298-299.
1935 Climate in relation to insect ecology in Australia. 1. Mean monthly precipitation and atmospheric saturation deficit in Australia. Trans. Roy. Soc. S. Aust., **58**, 197-210. 2. Mean monthly temperature and precipitation-evaporation ratio. Trans. Roy. Soc. S. Aust., **59**, 107-124.
1936 The apple-thrips (*Thrips imaginis* Bagnall) in South Australia). Jour. Dept. Agric. S. Aust., **39**, (7), 930-939.
1936 On the ecology of the black-tipped locust (*Chortoicetes terminifera* Walk.) in South Australia. Trans. Roy. Soc. S. Aust., **60**, 137-152.
1936 Climate in relation to insect ecology in Australia. 3. Bioclimatic zones in Australia. Trans. Roy. Soc. S. Aust., **60**, 88-92.
1937 The temperature-development curve of *Lyperosia exigua* de Meijere (Diptera, Muscidae) in relation to the probable distribution of this insect in Australia. Aust. Jour. Exp. Biol. and Med. Sci., **15**, (2), 113-120.
1938 The "grasshopper" problem in South Australia. Andrewartha, H. G., Davidson, J., and Swan, D. C. Jour. Dept. Agric. S. Aust., **41**, (6), 565-571.
1938 Vegetation types association with plague "grasshoppers" in South Australia. Andrewartha, H. G., Davidson, J., and Swan, D. C. Bull. Dept. Agric. S. Aust., No. 333.
1938 The locust and grasshopper problem in South Australia. Jour. Dept. Agric. S. Aust., **42**, (3), 241-249.
1940-41 Wheat storage problems in South Australia. Jour. Dept. Agric. S. Aust., **44**, (3, 5, 7-8), 124-136, 243-247, 346-352, 391-395.
1942 On the speed of development of insect eggs at constant temperatures. Aust. Jour. Exp. Biol. and Med. Sci., **20**, (4), 233-239.
1942 Flies, fleas and lice. Med. Jour. Aust., 111.
1943 The incubation period of the eggs of *Halotydeus destructor* Tucker (Acarina) at different temperatures, Davidson, J., and Swan, D. C. Aust. Jour. Exp. Biol. and Med. Sci., **21**, (3), 107-110.
1944 On the growth of insect populations with successive generations. Aust. Jour. Exp. Biol. and Med. Sci., **22**, (2), 95-103.
1944 On the relationship between temperature and rate of development of insects at constant temperatures. Jour. An. Ecol., **13**, (1), 26-38.

H. G. ANDREWARTHA

Waite Agricultural Research Institute,
25 October 1945

HORACE EDGAR DUNSTONE, M.B., B.S.

Horace E. Dunstone passed away on 13 July after a brief illness. The son of Mr. John Dunstone, of Beetaloo, South Australia, he received his earlier

education at Le Fevre Peninsula School and Largs Bay College. Later, entering the University of Adelaide, he graduated M.B., B.S. in 1912. He was a Fellow of the Society from 1932, and although not an active Fellow in our affairs, he was a keen member and supporter of the Field Naturalists' Section and of the Shell Club. He was keenly interested in municipal, as well as social and sporting organisations, and at the time of his death was the Mayor of St. Peters.

His eldest son, Dr. Sidney Dunstone, is a Fellow of the Society.

JAMES THOMAS WILSON

Professor James Thomas Wilson, M.B. (Edin.), M.D., Ch.M. (Sydney), M.A. (Cantab.), LL.D. (Edin.), F.RS, FZ.S., an Honorary Fellow of the Royal Society of South Australia since the year 1894, passed away in September last. At the time of his death he was Emeritus Professor of Anatomy in the University of Cambridge.

Having graduated M.B. at the University of Edinburgh in 1883, he was appointed Challis Professor of Anatomy in the University of Sydney in the year 1890. There, for many years, he served with academic distinction until appointed in the year 1920 to the Chair of Anatomy in the University of Cambridge, which he occupied until retiring in 1934.

ERRATA AND CORRIGENDA

In Part 1 of this volume:—

p. 27, second line, for "south" read "east."
p. 32 and p. 34, for "W. T. Dalwood" read "T. W. Dalwood."
p. 37, in line 35, after "inclusions" insert "in."
p. 37, in line 47, between "ilmenite" and "leucoxene" insert "and."
p. 37, after "leucoxene" on last line, add "these are rarely embedded in the sphene itself but occur in the junctions of the felspar and quartz pockets with that mineral."
p. 42, in last line, for "fig. 3" read "fig. 4."
p. 46, in line 14 from bottom, for "fig. 4" read "fig. 3."

BALANCE SHEET

Summary

ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)

Receipts and Payments for the Year ended 30 September 1945

RECEIPTS

	£	s.	d.	£	s.	d.
To Balance, 1 October 1944				263	15	2
„ Subscriptions				161	14	0
„ Life Member Composition				15	15	0
„ Government Grant for printing, etc.				442	4	2
„ Sale of Publications and Reprints:—						
University of Adelaide	89	16	3			
Sundries	58	3	4			
				147	19	7
„ Use of Room	5	14	0			
Exchange	–	3	2			
				5	17	2
„ Interest — Transferred from Endowment Fund				198	0	11
				£1,235	6	0

PAYMENTS

	£	s.	d.	£	s.	d.
By Transactions Vol. 68, Pt. 1 & 2; Vol. 69, pt. 1)—						
Printing	679	4	2			
Illustrating	217	1	2			
Publishing	21	16	3			
				918	1	7
„ Reprints				57	19	10
„ Librarian				31	8	0
„ Sundries—						
Cleaning Rooms	11	2	6			
Lighting	3	4	6			
Printing, Postages and Stationery	23	16	2			
Petties & Cheque Book	4	7	6			
Epidiascope	1	1	0			
Insurances	6	10	0			
				50	1	8
„ Endowment Fund				15	15	0
„ Balances—30 Sep. 1945—						
Savings Bank of S.A...	147	17	10			
Bank of Aust. £22 2 8 *Less* Outstanding Chqus. 8 15 7	13	7	1			
„ Cash to Bank	–	15	0			
				161	19	11
				£1,235	6	0

ENDOWMENT FUND as at 30 September 1944

(Capital—Stocks, etc., Face Value, £6,027 3s. 7d.; Cost, £6,025 13s. 7d.)

	£	s.	d.	£	s.	d.
1944—October 1						
To Balance—						
Aust. Inscribed Stocks	5,812	0	0			
Savings Bank of S.A.	9	4	10			
				5,821	4	10
„ Life Member Composition				15	15	0
„ Capital Increment— Exchange of Stock				188	13	9
„ Interest—						
Inscribed Stock	195	5	5			
Savings Bank of S.A.	2	15	6			
				198	0	11
				£6,223	14	6

	£	s.	d.	£	s.	d.
1945—September 30						
By Revenue Account				198	0	11
„ Balance—						
Aust. Inscribed Stocks	6,008	10	0			
Savings Bank of S.A. ..	17	3	7			
				6,025	13	7
				£6,223	14	6

Audited and found correct. We have verified the holding of Stocks at the Registry of Inscribed Stock, Adelaide, and the respective Bank Balances.

O. GLASTONBURY, F.A.I.S., A.F.I.A. } Hon.
F. M. ANGEL } Auditors

HERBERT M. HALE,
Hon. Treasurer

Adelaide, 10 October 1945

AWARDS OF THE SIR JOSEPH VERCO MEDAL AND LIST OF FELLOWS, MEMBERS, ETC.

Summary

AWARDS OF THE SIR JOSEPH VERCO MEDAL

1929 Prof. Walter Howchin, F.G.S.
1930 John McC. Black, A.L.S.
1931 Prof. Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
1933 Prof. J. Burton Cleland, M.D.
1935 Prof. T. Harvey Johnston, M.A., D.Sc.
1938 Prof. J. A. Prescott, D.Sc., F.A.I.C.
1943 Herbert Womersley, A.L.S., F.R.E.S.
1944 Prof. J. G. Wood, D.Sc., Ph.D.
1945 Cecil T. Madigan, M.A., B.E., D.Sc., F.G.S.

LIST OF FELLOWS, MEMBERS, ETC.

AS ON 30 SEPTEMBER 1945

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary.

Note—The publications of the Society are not sent to those members whose subscriptions are in arrear.

Date of Election.

Honorary Fellow

1945. *Black, J. M., A.L.S., A.L.S. (*Hon. causa*), 82 Brougham Place, North Adelaide—Fellow, 1907-45; **Verco Medal**, 1930; **Council**, 1927-31; **President**, 1933-34; **Vice-President**, 1931-33.

1945. *Fenner, C. A. E., D.Sc., Rose Park, Adelaide—Fellow, 1917-45; **Council**, 1925-28; **President**, 1930-31; **Vice-President**, 1928-30; **Secretary**, 1924-25; **Treasurer**, 1932-33; **Editor**, 1934-37.

Fellows.

1935. Adam, D. B., B.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council**, 1939-42; **Vice-President**, 1942-; **Librarian**, 1942-.

1927. *Alderman, A. R., Ph.D., M.Sc., F.G.S., Div. Indus. Chemistry, C.S.I.R., Box 4331, G.P.O., Melbourne, Victoria—**Council**, 1937-42.

1931. Andrew, Rev. J. R., c/o 212 Young Street, North Unley.

1935. *Andrewartha, H. G., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide.

1935. *Andrewartha, Mrs. H. V., B.Agr.Sc., M.S., 29 Claremont Avenue, Netherby, S.A.

1929. Angel, F. M., 34 Fullarton Road, Parkside, S.A.

1939. *Angel, Miss L. M., M.Sc., c/o 2 Moore Street, Toorak, Adelaide.

1936. Barrien, Miss B. S., M.Sc., University, Adelaide.

1945. Bartlett, H. K., L.Th., Burra, S.A.

1932. Begg, P. R., D.D.Sc., L.D.S., Shell House, 170 North Terrace, Adelaide.

1928. Best, R. J., M.Sc., F.A.C.I., Waite Institute (Private Mail Bag), Adelaide.

1940. *Birch, L. C., B.Agr.Sc., M.Sc., Waite Institute (Private Mail Bag), Adelaide.

1934. Black, E. C., M.B., B.S., Magill Road, Tranmere, Adelaide.

1945. Blackett, Rev. A. H., B.A., B.D., Methodist Manse, Salisbury, S.A.

1945. Bonython, C. W., B.Sc., A.A.C.I., 269 Domain Road, South Yarra, S.E. 1, Vict.

1940. Bonython, Sir J. Lavington, 263 East Terrace, Adelaide.

1944. Burbidge, Miss N. T., M.Sc., 242 Portrush Road, Glen Osmond, S.A.

1923. Burdon, R. S., D.Sc., University, Adelaide, S.A.

1922. *Campbell, T. D., D.D.Sc., D.Sc., Dental Dept., Adelaide Hospital, Adelaide—**Council**, 1928-32, 1935, 1942-45; **Vice-President**, 1932-34; **President**, 1934-35.

1944. Casson, P. B., B.Sc., For. (Adel.), Dept. For., Mount Crawford Forest, S.A.

1929. Christie, W., M.B., B.S., Education Department, Social Services, 51 Pirie Street Adelaide—**Treasurer**, 1933-38.

1895. *Cleland, Prof. J. B., M.D., University, Adelaide—**Verco Medal**, 1933; **Council**, 1921-26, 1932-37; **President**, 1927-28; 1940-41; **Vice-President**, 1926-27, 1941-42.

1929. Cleland, W. P., M.B., B.S., M.R.C.P., Dashwood Road, Beaumont.

1930. *Colquhoun, T. T., M.Sc., 10 French Street, Netherby, S.A.—**Secretary**, 1942-43.

Date of Election.

1938. *Condon, H. T., S.A. Museum, Adelaide.
1907. Cooke, W. T., D.Sc., A.A.C.I., University, Adelaide—**Council**, 1938-41, **Vice-President**, 1941-42, 1943-44; **President**, 1942-43.
1942. Cooper, H. M., 51 Hastings Street, Glenelg, S.A.
1944. Cornish, Melville, State Bank, Pirie Street, Adelaide.
1929. *Cotton, B. C., S.A. Museum, Adelaide—**Council**, 1943-
1945. Cowell, D. C., "Sunnymeade," Kalangadoo, S.A.
1924. de Crespigny, Sir C. T. C., D.S.O., M.D., F.R.C.P., 219 North Terrace, Adelaide.
1937. *Crocker, R. L., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Secretary**, 1943-45.
1927. *Davies, Prof. E. H., Mus.Doc., The University, Adelaide.
1941. *Dickinson, S. B., B.Sc., Mines Department, Flinders Street, Adelaide.
1930. Dix, E. V., Hospitals Department, Rundle Street, Adelaide, S.A.
1944. Dunstone, S. M. L., M.B., B.S., 124 Payneham Road, St. Peters, Adelaide.
1921. Dutton, G. H., B.Sc., 12 Halsbury Avenue, Kingswood, Adelaide.
1931. Dwyer, J. M., M.B., B.S., 25 Port Road, Bowden. (A.I.F. abroad.)
1933. *Eardley, Miss C. M., B.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council**, 1943-
1945. Edmonds, S. T., B.A., B.Sc., 56 Fisher Terrace, Mile End, S.A.
1902. *Edquist, A. G., 19 Farrell Street, Glenelg, S.A.
1935. *Fenner, F. J., M.B., B.S., 42 Alexandra Avenue, Rose Park. (A.I.F. abroad.)
1944. Ferres, Miss H. M., 8 Taylor's Road, Mitcham, S.A.
1927. *Finlayson, H. H., 305 Ward Street, North Adelaide—**Council**, 1937-40.
1923. *Fry, H. K., D.S.O., M.D., B.S., B.Sc., F.R.A.C.P., Town Hall, Adelaide—**Council**, 1933-37; **Vice-President**, 1937-38, 1939-40; **President**, 1938-1939.
1932. *Gibson, E. S. H., B.Sc., 297 Cross Roads, Clarence Gardens, Adelaide.
1935. *Glastonbury, J. O. G., B.A., M.Sc., Dip.Ed., Armament School, R.A.A.F., Nhill, Victoria.
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1935. †Goldsack, H., Coromandel Valley.
1939. Goode, J. R., B.Agr. Sc., Box 180, G.P.O., Whyalla, S.A.
1925. †Gosse, J. H., Gilbert House, Gilbert Place, Adelaide.
1910. *Grant, Prof. Kerr, M.Sc., F.I.P., University, Adelaide.
1930. Gray, J. T., Orroroo, S.A.
1933. Greaves, H., Director, Botanic Gardens, Adelaide.
1904. Griffith, H. B., Dunrobin Road, Brighton, S.A.
1934. Gunter, Rev. H. A., 10 Broughton Street, Glenside, S.A.
1944. Guppy, D. J., B.Sc., R.A.A.F., 11 Marten Avenue, Fitzroy.
1922. *Hale, H. M., Director, S.A. Museum, Adelaide—**Council**, 1931-34; **Vice-President**, 1934-36, 1937-38; **President**, 1936-37; **Treasurer**, 1938-.
1944. Harris, J. R., B.Sc., 3 Airlie Avenue, Prospect, S.A.
1939. Harvey, Miss A., B.A., Dequetteville Terr., Kent Town, Adelaide.
1944. Herriot, R. I., B.Agr.Sc., Soil Conservator, Dept. of Agriculture, S.A.
1927. Holden, The Hon. E. W., B.Sc., 175 North Terrace, Adelaide.
1924. *Hossfeld, P. S., M.Sc., 132 Fisher Street, Fullarton, S.A.
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1928. Ifould, P., Kurralta, Burnside, S.A.
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1918. *Jennison, Rev. J. C., 7 Frew Street, Fullarton, Adelaide.
1945. Jessup, R. W., B.Sc., 51 Harriet Street, Croydon Park.
1910. *Johnson, E. A., M.D., M.R.C.S., "Tarni Warra," Port Noarlunga, S.A.
1921. *Johnston, Prof. T. H., M.A., D.Sc., University, Adelaide—**Verco Medal**, 1935; **Council**, 1926-28, 1940-; **Vice-President**, 1928-31; **President**, 1931-32; **Secretary** 1938-40; **Rep. Fauna and Flora Board**, 1932-39; **Editor**, 1943-.
1939. †Khakhar, H. M., Ph.D., M.B., F.R.G.S., Khakar Buildings, C.P. Tank Road, Bombay, India.
1933. *Kleeman, A. W., M.Sc., University, Adelaide.
1939. Leask, J. C., A.M.I.E., 9 Buller Street, Prospect, S.A.
1922. Lendon, G. A., M.D., B.S., F.R.C.P, A.M.P. Building, King William Street, Adelaide.
1938. *Love, Rev., J. R. B., M.C., D.C.M., M.A., Ernabella, via Oodnadatta, S.A.
1931. *Ludbrook (Mrs. W. V.), N. H., M.A., Elimatta Street, Reid, A.C.T.
1938. Madden, C. B., B.D.S., D.D.Sc., Shell House, North Terrace, Adelaide.
1922. *Madigan, C. T., M.A., B.E., D.Sc., F.G.S., University of Adelaide—**Council**, 1929-33, **Vice-President**, 1933-35, 1936-37; **President**, 1935-36.
1933. Magarey, Miss K. de B., B.A., B.Sc., 19 Ashbourne Avenue, Mitcham, S.A.
1932. Mann, E. A., C/o Bank of Adelaide, Adelaide.

Date of Election.

1923. MARSHALL, J. C., c/o 16 May Terrace, Kensington Park, Adelaide.
1939. MARSHALL, T. J., M.Agr.Sc., Ph.D., Waite Institute (Private Mail Bag), Adelaide.
1929. MARTIN, F. C., M.A., Technical High School, Thebarton, S.A.
1905. *MAWSON, PROF. SIR DOUGLAS, O.B.E., D.Sc., B.E., F.R.S., University, Adelaide—**Verco Medal,** 1931; **President,** 1924-25, 1944-45; **Vice-President,** 1923-24, 1925-26; **Council,** 1941-43.
1938. *MAWSON, MISS P. M., M.Sc., University, Adelaide.
1920. MAYO, THE HON. MR. JUSTICE, LL.B., K.C., 16 Pirie Street, Adelaide.
1943. McCARTHY, MISS D. F., B.A., B.Sc., 70 Halton Terrace, Kensington Park.
1934. McCLOUGHRY, C. L., B.E., A.M.I.E., (Aust.), Box 1058 J, G.P.O., Adelaide.
1944. McGILP, L. K., Ramsgate Hotel, Henley Beach, S.A.
1944. MILES, K. R., D.Sc., F.G.S., Mines Department, Flinders Street, Adelaide.
1939. MINCHAM, V. H., Willaloo, via Hallett, S.A.
1925. †MITCHELL, PROF. SIR W., K.C.M.G., M.A., D.Sc., Fitzroy Ter., Prospect, SA.
1933. MITCHELL, PROF. M. L., M.Sc., University, Adelaide.
1938. MOORHOUSE, F. W., M.Sc., Chief Inspector of Fisheries, Flinders Street, Adelaide.
1940. MORTLOCK, J. A. T., 37 Currie Street, Adelaide.
1936. *MOUNTFORD, C. P., 25 First Avenue, St. Peters, Adelaide.
1944. MURRELL, J. W., Engineer and Waters Dept., Port Road, Thebarton, S.A.
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1913. *OSBORN, PROF. T. G. B., D.Sc., Department of Botany, Oxford, England—**Council,** 1915-20, 1922-24; **President,** 1925-26; **Vice-President,** 1924-25, 1926-27.
1937. *PARKIN, L. W., M.A., B.Sc., c/o Mines Department, Flinders Street, Adelaide.
1945. PATTISON, G., 68 Partridge Street, Glenelg, S.A.
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1926. *PIPER, C. S., D.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1941-43; **Vice-President,** 1943-45.
1925. *PRESCOTT, PROF. J. A., D.Sc., A.I.C., Waite Institute (Private Mail Bag), Adelaide—**Verco Medal,** 1938; **Council,** 1927-30, 1935-39; **Vice-President,** 1930-32; **President,** 1932-33.
1926. PRICE, A. G., C.M.G., M.A., Litt.D., F.R.G.S., 46 Pennington Terrace, North Adelaide.
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1942. PUGSLEY, A. T., B.Ag.Sc., M.Sc., Waite Institute (Private Mail Bag), Adelaide.
1937. *RAIT, W. L., M.Sc., Medical School, University of Melbourne, Carlton N. 3, Victoria
1944. RICEMAN, D. S., B.Agr.Sc., Animal Nutrition Labor., Univ., Adelaide.
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1945. RYMILL, J. R., Old Penola Estate, Penola, S.A.
1944. SANDARS, MISS D. F., Zoology Department, University, Adelaide.
1933. SCHNEIDER, M., M.B., B.S., 175 North Terr., Adelaide.
1924. *SEGNIT, R. W., M.A., B.Sc., Engineering and Water Supply Department, Victoria Square, Adelaide—**Secretary,** 1930-35; **Council,** 1937-38; **Vice-President,** 1938-39, 1940-41; **President,** 1939-40.
1925. *SHEARD, H., Port Elliot, S.A.
1936. *SHEARD, K., Fisheries Research Div. C.S.I.R., c/o Institute of Agriculture, Univ., W.A.
1945. SHEPHERD, J. H., B.Sc., B.A., Waite Institute (Private Mail Bag), Adelaide.
1934. SHINKFIELD, R. C., Salisbury, S.A.
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1938. *SIMPSON, MRS. E. R., M.Sc., Warland Road, Burnside.
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1944. SMITH, C. A. N., Waite Institute (Private Mail Bag), Adelaide, S.A.
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1941. SOUTHCOTT, R. V., M.B., B.S., 12 Avenue Road, Unley Pork, S.A.
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1932. SWAN. D. C., M.Sc., Waite Institute (Private Mail Bag), Adelaide — **Secretary,** 1940-42.
1934. SYMONS, I. G., Murray Street, Mitcham.
1929. *TAYLOR, J. K., B.A., M.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1940-43.

1940. THOMSON, J. M., 135 Military Road, Semaphore South.
1923. *TINDALE, N. B., B.Sc., South Australian Museum, Adelaide—**Secretary,** 1935-36. R.A.A.F.
1945. TIVER, N. S., B.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide.
1937. *TRUMBLE, PROF. H. C., D.Sc., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—**Council,** 1942-
1894. *TURNER, A. J., M.D., F.R.E.S., Dauphin Terr., Brisbane, Qld.
1925. TURNER, D. C., Brookman Buildings, Grenfell Street, Adelaide.
1912. *WARD, L. K., B.A., B.E., D.Sc., 22 Northumberland Avenue, Tusmore—**Council,** 1924-27, 1933-35; **President,** 1928-30; **Vice-President,** 1927-28.
1941. *WARK, D. C., M.Agr.Sc., Div. Plant Industry, C.S.I.R., Canberra, A.C.T.
1936. WATERHOUSE, MISS L. M., 35 King Street, Brighton, S.A.
1942. WATSON, R. H., Central Wool Committee Testing House, 572 Flinders Lane, Melb., C1.
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1931. WILSON, C. E. C., M.B., B.S., "Woodfield," Fisher Street, Fullarton, Adelaide.
1944. WILSON, E. C., M.A., B.Sc., 23 Palmer Avenue, Myrtle Bank, S.A.
1938. *WILSON, J. O., Animal Nutrition Laboratory, University, Adelaide.
1930. *WOMERSLEY, H., F.R.E.S., A.L.S. (*Hon. causa*), S.A. Museum, Adelaide—**Secretary,** 1936-37; **Editor,** 1937-43; **President,** 1943-44; **Verco Medal,** 1943; **Vice-President,** 1944-45; **Rep. Fauna and Flora Protection Committee,** 1945.
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1944. WOMERSLEY, J. S., 43 Carlisle Road, Westbourne Park, S.A.
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1923. *WOOD, PROF. J. G., D.Sc., Ph.D., University, Adelaide—**Council,** 1938-40; **Vice-President,** 1940-41; **Rep. Fauna and Flora Board,** 1940-; **President,** 1941-42; **Verco Medal,** 1944.
1943. WOODLANDS, HAROLD, Box 989 H, G.P.O., Adelaide.
1942. ZIMMER, W. J., Dip.For., F.L.S. (Lon.), 22 Docker Street, Wangaratta, Vict.

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